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## REPORT OF THE ENTOMOLOGIST

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UNITED STATES DEPARTMENT OF AGRICULTURE,  
BUREAU OF ENTOMOLOGY,  
*Washington, D. C., August 30, 1926.*

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1926.

Respectfully,

L. O. HOWARD,  
*Entomologist and Chief of Bureau.*

Hon. W. M. JARDINE,  
*Secretary of Agriculture.*

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### DECIDUOUS - FRUIT INSECT INVESTIGATIONS

Investigations of deciduous-fruit insects have been carried on under the direction of A. L. Quaintance, as in previous years.

#### PEACH INSECTS

Studies of the oriental peach moth have been continued in New Jersey and Georgia. It has been found that it develops five broods of larvæ each year at Riverton, N. J. Some of the third-brood larvæ, many of the fourth brood, and all of the fifth overwinter in cocoons. Its parasites play a very important part in peach orchards under New Jersey conditions. Two important species have been extensively studied, one a parasite of the egg and the other of the larva. An attractive bait for the moths has been sought. It has been found that fermenting molasses is attractive to these insects and that about 50 per cent of the insects captured were females which had not yet deposited their eggs. Numerous details concerning bait traps are being looked into, such as the type of container and the height of bait from the ground. Cultivation tests were conducted during the spring of 1926 which showed that the overwintering stages in the soil may be destroyed almost completely by two thorough cultivations previous to the issuing of the adults. These cover the insects so deeply in the ground that the moths can not escape. Several

promising insecticides are being tested in the laboratory preliminary to field trials.

Studies on the biology of the oriental peach moth in Georgia have been continued in the laboratory and field and tests have been made of various baits to attract the moths. The prophecy made in my last annual report that the peach moth under Georgia conditions will not be a serious peach pest has been confirmed. The reason is that the latest variety commercially grown matures about midsummer, greatly interfering with the late summer and fall food supply of the larvæ. This is considered very fortunate in view of the fact that the insect during the season of 1925 developed seven generations of larvæ under laboratory conditions in Georgia.

Plum-curculio studies in Georgia have practically been concluded and a comprehensive report on the work has been prepared. The curculio-suppression campaign appears to have been most successful, since not a single complaint of curculio damage to ripe peaches came to the Fort Valley laboratory during 1926. We are now trying to learn the factors involved in arsenical injury to peach foliage and fruit. Tests of other materials for peach spraying have been made, such as the fluosilicates of sodium and calcium, and coated arsenate of lead. Studies have been continued of para-dichlorobenzene against the peach borer and a manuscript including the results of 'five years' work on this

material in Georgia has about been completed. Tests of calcium cyanide as a borer fumigant indicate that the trees are injured by doses large enough to kill the borers.

In cooperation with the Purdue Agricultural Experiment Station, tests conducted during the spring of 1926 at Vincennes, Ind., have shown conclusively that the so-called "cat face" of peaches is caused by two or three species of true bugs, the tarnished plant bug being responsible for the major part. Some of it, however, is caused by two species of *Euschistus*. The types of injury of these insects are well distinguished. Apparently none of them feed to any extent on larger fruit, the injury occurring within a short period after they have fed on the blossoms and small peaches in late spring and early summer. The cleanest orchards are less likely next season to have injured peaches, since late in the season these insects feed largely on weeds. Further tests of paradichlorobenzene have been made on 2-year-old peach trees in late August under extremely high soil temperature and in a very dry soil. Although some small injury resulted, this seemed to have no permanent effect on the trees. It would appear, therefore, that in the Vincennes, Ind., territory the treatment of young peach trees with this chemical in the fall is reasonably safe and less likely to damage the trees than the usual method of worming. On the other hand, the treatment of peach seedling stock in nurseries resulted in serious injury and a number of trees were killed. Observations on the plum curculio in the Vincennes region indicate that the insect may there develop a partial second brood during certain seasons. Wormy peaches at harvest time, however, mostly result from late oviposition of the longest-lived adults of overwintering beetles.

#### GRAPE INSECTS

Work with grape insects at Sandusky, Ohio, in cooperation with the Ohio Agricultural Experiment Station has been continued. The method of applying sprays to vineyards has been further improved, especially the utilization of the "boom" method to meet the various needs of spray applications for the grape-leaf hopper and grape-berry moth. Results from tests of the improved boom in the control of the grape-berry moth compare favorably so far with those obtained by the slow and expensive hand or trailer system of spraying.

There is further evidence that nicotine sulphate, in the early spray applications has an effect on the eggs of the grape-leaf hopper. In the Sandusky and Lake Erie Island grape district it has been found that at the time grapes are in condition for spraying for the grape-berry moth, a few days after the grape blossoms have fallen, many nymphs of leaf hoppers have hatched and most of the eggs of the overwintering brood of hoppers have already been deposited in the grape leaves. Nicotine sulphate in grape-berry-moth sprays applied at this time has shown very satisfactory control of the leaf hoppers and is especially valuable in regions where the three-banded grape-leaf hopper predominates.

Studies of the biology of grape-leaf hoppers have been practically completed and include results of several seasons' work. The continued ravages of the rose chafer have necessitated some cooperative work with the State extension service and the State Department of Agriculture of Pennsylvania. Many materials have been tested and a report on the work will soon be prepared. The widespread interest in vineyard dusting, due to demands for methods which require less time than hand spraying, has made it desirable to give special attention to commercial dusting machinery and materials adapted for vineyard use. Although preliminary tests of dust have shown fair control of grape-leaf hoppers under suitable weather conditions, additional work will be necessary before we can judge definitely as to their efficiency in comparison with sprays.

#### CODLING MOTH

During the growing season of 1925 the codling moth was unusually abundant and destructive in many of the principal apple-growing regions. This came about from a variety of causes, especially favorable spring temperatures for oviposition of the moths and warm, droughty conditions during mid-summer which favored the development of additional broods. Its damage was especially severe in Kansas and the Ozarks where, in spite of persistent spraying, the quantity of sound fruit at harvest time was greatly reduced.

To meet the situation in Kansas, funds were appropriated by Congress for an investigation of the insect in that State, effective July 1, 1926. In order to cover an entire season, however, arrangements were made to begin investigations, in cooperation with

the Kansas Agricultural College, during the spring with headquarters at Wichita. It is believed that the studies planned and under way will throw much light on the factors involved in the codling-moth problem in that State as well as throughout that general region.

At the Bentonville, Ark., laboratory field experiments in control are being conducted which involve variations in application. This includes the testing of arsenicals applied in various dosages and at various times, and of ovicidal and larvicidal materials. In the spring of 1926, codling-moth studies of questions relating to the quantity of spray residue on fruit at harvest time were undertaken as a major project at the Yakima, Wash., field station. Tests of a large series of baits for moths in the orchard and in packing sheds are also being made. An apple ferment has been found to be the best bait material of those tried, though a ferment of molasses and yeast is also good. Of the various essential oils tested, none show much promise.

At the Sligo, Md., laboratory studies are being made of the feeding habits of the codling-moth larvæ, especially those just hatched, as bearing upon a more effective means of control. The development of insecticides other than the arsenicals is being attempted. At a conference on codling-moth problems in the spring between representatives of the bureau and cooperating entomologists, a thoroughgoing outline of study was prepared which gives special attention to the physiology and behavior of the insect as affording possibilities for more effective control, and by means less objectionable than those now employed.

#### NUT INSECTS

Further progress has been made in the investigation of insects attacking nuts, both in the northern States and in the South. At the French Creek, W. Va., laboratory, studies of the biology of several species of cureulios attacking chestnut and hazelnut were practically completed. The hickory twig girdler, a serious pest of pecans in Virginia and North Carolina, as well as several species of *Agrilus* beetles, have been studied. A report has been submitted on *Agrilus arcuatus* Say, which is seriously injurious to young hickory and other nut-bearing trees.

During the year part of a chestnut orchard located at Bell, Md., was sprayed several times with an arseni-

cal poison in an attempt to check destructive attack by chestnut weevils. Counts of infested nuts of both sprayed and untreated trees showed at the end of the season that the number of larvæ attacking the nuts had been reduced slightly more than 50 per cent by spraying. Infestation, however, was still so extensive that the experiment could not be called a practical success. In view of the fact that species of chestnuts have been found sufficiently resistant to chestnut blight to warrant their planting under certain conditions for nut-bearing purposes, it is felt that further work of this kind should be done.

At the Thomasville, Ga., station work has been confined to a study of the insects injurious to the pecan. In addition to biologic studies of the various species involved, such as the pecan weevil, pecan nut case bearer, pecan shuck worm, and bud moth, attention has been given to control experiments in pecan groves. Various baits likely to attract the moths have been tested. The results thus far have not been very encouraging, but further tests may develop something of value. Additional tests of sprays for the control of the nut case bearer and leaf case bearer are being made. These involve the use of a number of oil emulsions and miscible oils to determine the relative extent to which they will penetrate the winter cases and kill the larvæ. Calcium arsenate, arsenate of lead, and sodium silicofluoride have been applied to trees for the control of the nut case bearer with results not yet checked. Experiments with dusts are also under way, involving various strengths of arsenate of lead and calcium arsenate.

At the Brownwood, Tex., substation for pecan-insect investigations additional biologic data have been accumulated on the various insects injurious to the pecan in that region. In spraying and dusting experiments in the control of the nut case bearer it was found that two applications of arsenate of lead spray, at the rate of 1 pound of the powder to 50 gallons of water to which was added 4 pounds of hydrated lime, soon after the nuts had set, with an interval of about 10 days, and a third application four weeks after the second, gave best results. The damage was reduced from 39 per cent on the untreated plots to 10 per cent on those treated. More than 1 pound of the arsenate of lead to 50 gallons of water gave no additional control. A reduction of over 20 per cent in injury was obtained with three

applications of an arsenical dust composed of 10 per cent arsenate of lead and 90 per cent of hydrated lime. Spraying experiments have been carried out during the dormant season against the so-called obscure scale which is becoming a pecan-insect pest of considerable note. Some degree of control was obtained with various homemade and proprietary oil sprays, but the cooked lubricating-oil emulsions gave best results. Incidentally the *Phylloxera* was reduced by these sprays.

#### BLUEBERRY MAGGOT

Beginning July 1, 1925, an investigation of the so-called blueberry maggot in Maine was undertaken with headquarters at Harrington. The balance of the summer and fall was largely used in making preliminary surveys, establishing experimental plots, and conducting a general study of the blueberry-maggot situation as existing in Washington County. The blueberry pack in Washington County is said to be valued at more than a million dollars annually, the crop being the most important agricultural product of the county. The blueberry maggot is, when abundant, found in the blueberries after canning, rendering them unsuitable for food. It has been the practice to burn a portion of the acreage every third year and this is generally believed to be destructive to the puparia of the insects in the soil. An investigation shows that this is doubtful, but further experiments will be necessary before positive statements will be warranted. There is, however, apparently an indirect benefit from burning, especially over large areas, through reduction of the food supply of the insects during the following two seasons. The extent of benefit will depend upon the ability of the flies to come in from unburned areas, or the possibility of the puparia carrying over in the soil two years. These points must be studied further. Careful rearing experiments indicate that the adult or fly of the blueberry maggot emerges principally from early July to early August, though this conclusion may be changed by further observations. Experiments are being conducted with calcium arsenate and arsenate of lead dusted over the plants to poison the adults when feeding. This method of maggot control has proved of considerable value in the case of this insect in orchards. Preliminary observations indicate that there was a marked reduction of the

flies on the treated areas as compared with the untreated plots. If it is found that dusting plants with arsenicals during the period of emergence of the flies is a satisfactory remedy, various practical details will require attention, since much of the blueberry barrens are low-yielding lands, paying very small returns. Large-scale growers are already interested in the possibility of applying arsenical dusts by means of airplanes.

#### ORCHARD INSECTICIDES

Further attention has been given to the dipyrityls and allied compounds as contact insecticides. Some 20 mixtures containing dipyrityls have been prepared and tested for insecticidal action, one of which has shown considerable toxicity. This is a joint project with the Bureau of Chemistry. Further studies of pyrroles and related compounds have been made and several toxic materials found. Interesting information has been obtained about the relation between chemical structure and toxicity.

The several projects involving oil investigations in cooperation with the Bureau of Chemistry, alluded to in the last report, have been continued and substantial progress made. Two modifications of existing cold-stirred emulsions have been proposed and reported upon. A field method of estimating the percentage of oil in concentrated and spray-strength emulsions has also been published. A study of the size of oil drops in emulsions as related to toxicity to insects has been completed. These studies seem to explain in part why miscible-oil sprays are not so toxic as ordinary soap emulsions when the same oil is used in the two preparations. These and other oil studies in cooperation with the Bureau of Chemistry and various field stations of the Bureau of Entomology are gradually bringing together an increased knowledge of oils and how they may best be used under varying practical conditions.

Further improvement has been made in an insect "olfactometer," and by its use considerable progress has been made in determining the reaction of various species of insects to odors from plant extracts, from plants, and from insects themselves. This field of investigation is promising as pointing out ways for the utilization of materials to attract insects to their destruction, or to repel them from plants. A paper on the senses of the cotton



boll weevil has been prepared. This paper also deals with the general subject of how plants attract insects by smell and it is believed will stimulate further research in this important field.

### PREVENTING SPREAD OF THE JAPANESE BEETLE

This work now forms a distinct section of the bureau in charge of Loren B. Smith. Several phases of investigational work on the Japanese beetle have been brought to a close during the year. New conditions have brought to light several problems on which it has been necessary to undertake somewhat detailed studies in order to work out the necessary solutions. As a result of the spread during the summer of 1925 it was necessary to increase the quarantined area from 5,122 square miles to 6,047 square miles. This has increased the work of certification of nursery stock and farm products, the movement of which is regulated under State and Federal quarantines. The investigational phases of the work have been broadened and an additional man has been established in India to work on the foreign parasites.

A material known as coated arsenate of lead has been developed which is used as a spray. It consists of arsenate of lead intimately mixed with lead oleate and suspended in water in the form of a paste. The advantage which this material offers over arsenate of lead consists in greater adhesive properties, thereby reducing the number of sprayings which may be necessary to effect the control of the insect. This material is recommended for use on shade trees and ornamental plants. It is unsafe, however, to use it as a general fruit spray since there is danger that too large quantities of arsenic will remain on the fruit at the time of harvest. It is now commercially manufactured and is on the market.

Pyrethrum soap was developed as a contact killer. It has given satisfactory results as a contact spray and, under experimental conditions, kills of 95 to 98 per cent have been made. This material has proved harmless to plants and most varieties can be sprayed several times in close succession without injury to the foliage. The formula for the preparation of the pyrethrum soap has been published, and the soap has been placed on the market by several insecticide companies. The beetles can be at-

tracted in large numbers to a small area with geraniol and then killed with the contact spray.

Under commercial conditions it was found that the alcoholic carbon-disulphide emulsion developed a year ago has certain properties which make it necessary to again improve the formula. This has resulted in the final development of a sodium-oleate carbon-disulphide emulsion, to which is added a small amount of resin. With this improved formula the depth at which a complete kill of the larvæ of the Japanese beetle in the soil can be obtained is increased, and also the danger of injury to the plants is reduced. It is now manufactured and available for general use. The carbon-disulphide emulsion developed at the Japanese beetle laboratory has been adopted in the control of several other insect pests which have hitherto been extremely difficult to suppress. Its use on nursery stock and on lawns and golf courses has been extended and the cost of treatment reduced through improvements in the formula as well as in methods of application.

It appears that arsenate of lead placed in the soil under certain conditions remains effective as a stomach poison for the larvæ of the Japanese beetle for a period of several years. Its effectiveness apparently depends upon the thoroughness with which the arsenate-of-lead powder is mixed with the soil. This has led to the development of a method of treating golf greens that is effective for several years. It was also found that this treatment results in a decrease in the number of weeds and a much purer stand of grass. It is efficacious also against earthworms and other soil-inhabiting insects.

Studies have been continued relative to the development of an arsenical substitute which can be used as a stomach poison for the adult Japanese beetle. In the course of the work the fluorides and silicofluorides of the various metals have been studied. The results of these experiments are not complete, although several hundred materials have been tested. At this stage of the investigational work the silicofluorides of barium and potassium and lead fluoride show promise, and on further investigation may be developed into extremely useful insecticides. In connection with this general study, naphthalene and its derivatives have received some attention as well as many other general chemicals.

Exhaustive studies have been conducted on soap emulsions of aniline, orthotoluidine, xylidine, derrisene, orthocresol, nitrobenzene, and other organic compounds and it has been found that orthotoluidine solutions have given very promising results as contact insecticides.

Extensive studies have been conducted relative to the control of the Japanese beetle under orchard conditions. The question of the protection of apples, peaches, and grapes has received additional attention since it has developed that at the time the Japanese beetle sprays are applied there may be danger, under certain conditions, in applying large quantities of lead arsenate.

Studies have been continued relative to the development of geraniol as an attractive agent for the Japanese beetle and methods have been worked out whereby this material may be used to concentrate the beetles in a relatively small area. It was found that by spraying less than an acre of orchard with geraniol beetles could be drawn in on the leeward side of the orchard for a distance of nearly one-half mile within the first 15 minutes after the spray had been applied. This makes it possible to destroy large numbers of beetles with a relatively small quantity of contact spray. Further work has been done on traps baited with geraniol, and although these will capture large numbers of beetles, it is not felt that a trap has been developed which can be recommended for general use. Increased efforts were made during the summer of 1925 to develop a repellent which could be used on fruit trees without leaving a deposit on the foliage or fruit. It was found that certain odors are distinctly repellent to the beetle, particularly the odor of tar.

General studies of the biology of the Japanese beetle have been continued. During the summer of 1925 large flights of beetles occurred, thousands alighting in Philadelphia on two separate occasions. This flight of dispersion was noticed during the summer of 1923 for the first time and lasted a relatively short time. The flight during the past season, however, was much more extensive, and the beetles occurred in the cities of Camden and Philadelphia in greater numbers than at any previous time. Observations indicate that they had flown a distance of several miles. These periodical flights are extremely serious from the standpoint of the

operation of the quarantine, since while they are in progress almost any public carrier or vehicle is likely to become infested.

Continued progress has been made in the liberation and rearing of several species of parasites. The tachinid fly *Centeter cinerea* Aldrich, introduced from Japan and found to be established in this country last year, survived the winter of 1925-26 in a satisfactory manner. Large shipments of the dextid fly *Prosema siberita* Fab. were received from Japan and successfully reared and liberated. It has been found possible to collect and ship adult *Tiphia* from China and Japan to Riverton, N. J., with relatively small mortality. As a result the method of handling the various species of solitary wasps has been changed and large shipments of the adults have been made. With this method of shipment much larger series have been liberated than were heretofore possible. Shipments of *Dexia ventralis* Aldrich were received in the spring of 1926, and it is anticipated that this valuable parasite can be successfully established.

The Bureau of Entomology has co-operated with the States of New Jersey, Pennsylvania, and Delaware, and with the Federal Horticultural Board in the enforcement of quarantines to prevent the spread of the Japanese beetle. These have been enforced to the fullest possible extent with the funds available. A revision of the quarantine, effective March 21, 1925, included an area of 5,122 square miles. A further increase in the quarantined area was made effective December 23, 1925. The area now under quarantine contains a population of more than three million people. During the summer of 1925 the inspection included sweet corn, peas and beans in the pod, vegetables with tops, hay, straw, and forage crops moving from the Philadelphia, Camden, Wilmington, and Trenton markets as well as direct from the farms. The inspection also included nursery, ornamental, and greenhouse products, sand, soil, earth, peat, compost, and manure. The inspection of farm products was operated during the period June 15 to October 15, whereas the inspection and regulation of the movement of nursery stock and nursery products was effective throughout the year.

As a result of the scouting operations in 1924, three beetles were found at Milton, Pa., at a distance of about 100 miles from the quarantined area. During the summer of 1925 an ex-



termination campaign was successfully conducted at this point.

In New Jersey 902,340 packages of farm products were certified for shipment to points outside the area between June 15 and October 15; 106,832 beetles were removed by inspectors from sweet corn, consigned largely to New York City; 7,223 beetles were removed from beans, and 61 beetles removed from miscellaneous produce. On the highways in New Jersey 11,264 trucks of produce were examined at the boundaries of the quarantined area to assure that the produce had been properly certified before leaving the quarantined zone. Two hundred and four vehicles stopped by road inspectors were found to be without the proper certificate. Eighteen wilful violators were prosecuted under laws of the State of New Jersey; 2 individuals were fined \$100 each; 5 were fined \$50 each, and 11 were found guilty and held under parole of the inspectors and assessed the costs of the court. A total of 17,503 carloads and 431 boatloads of sand or soil were certified and in many cases treated before certification for shipment out of the regulated area in New Jersey. These shipments were consigned to 35 States in addition to Canada, France, and Porto Rico. Six hundred and thirteen cars of hay or straw were shipped from the Hightstown area of New Jersey under certification to 12 States during the summer of 1925. Shipments of 24,235 bales of sphagnum moss were made under certification from New Jersey to 20 States. During the year January 1 to December 31, 1925, there were shipped from the Japanese beetle area under certification 13,404,396 nursery plants. These were consigned to every State in the Union and Province in Canada, and 13,888 to foreign countries.

The inspection and certification of farm produce in Pennsylvania relate particularly to the markets and commission houses in Philadelphia, since very little grown on farms outside of the city is shipped to points beyond the quarantined area. In all, 25,190 certificates were issued in Pennsylvania for the transportation of farm products to points outside the quarantined area, 95,842 for nursery stock, and 8,819 for carloads of sand. Efforts toward the enforcement of the quarantine were centered on the commercial carriers of produce, who transported large quantities from the markets. Unless there was visible evidence of violation private or touring

traffic was not interfered with on the roads. Through cooperation with the Pennsylvania State police a detail of the State constabulary was assigned to the Japanese-beetle project during the summer and greatly assisted in enforcement. Fifteen prosecutions were made against wilful violators of the quarantine provisions. Prosecutions were made under Pennsylvania State law, and in every case convictions were obtained and fines of \$5 to \$100 were obtained. In Pennsylvania a very large quantity of nursery stock was treated with carbon-disulphide emulsion that it might be shipped under certification. In the autumn of 1925, 10,421 treatments were made in 11 large nurseries. In the spring of 1926, 29,804 treatments were made; of these, 1,710 plants were rejected and not certified for various reasons. In Pennsylvania during the year 1,665,761 nursery plants were inspected and certified for shipment out of the area.

The quarantine work in the State of Delaware consisted largely in the inspection and certification of farm products; very little nursery stock is grown in the area now under quarantine in that State. Thirty-one carloads of sand were shipped out of the quarantined area under certification during the year. The State Department of Agriculture adopted a quarantine measure requiring inspection of all peaches consigned to points outside the regulated area. In all, 5,163 baskets and crates of peaches were inspected and 14 beetles were found. This State also maintains an inspection of empty baskets returned from Philadelphia to points beyond the quarantine line in Delaware. During the season 30,728 baskets were inspected. In all 86,047 packages of farm produce were inspected and certified for shipment to points outside the quarantined area in Delaware.

The system of quarantine operations has not been materially changed during the fiscal year. Inspectors are placed on all important roads leading out of the area for 24 hours a day and the road-inspection force is supplemented by State police wherever possible. It is the duty of the road inspectors to check up on vehicles hauling contraband articles out of the area. On all roads at the periphery of the area are placed large, conspicuous signs, stating the principal facts concerning the quarantine and the products under quarantine, for the information of the traveling public. Within the quarantined area temporary offices are maintained, where inspectors are stationed

and are available to the growers or shippers of produce on call to make the necessary inspections and certifications. Corps of inspectors are also maintained in the larger nurseries during the shipping season. In the enforcement of the nursery quarantine, where it is necessary to treat chemically the soil about the roots, a separate division of the quarantine organization is maintained, which performs the necessary treatments of all soil designed to be shipped out of the quarantined area. Scouting is systematically conducted by corps of men outside the known infested area in order to determine the annual spread of the insect. It has thus been possible to maintain an effective organization, both from the standpoint of the shipper and from that of enforcement of the stringent regulations.

#### **WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH**

This work has continued under the direction of A. F. Burgess. There has been close cooperation with all of the infested States with encouraging results.

#### **FIELD WORK IN THE BARRIER ZONE**

At the close of the last fiscal year an inspection of all the towns in the barrier zone in western New England and eastern New York was made and several small colonies found in towns that had not been scouted previously.

A group of towns directly west of the zone area in the Adirondack Mountain region, a number of towns in the Mohawk Valley and in the Catskill region, Westchester County, N. Y., and that portion of Connecticut between the zone and the New York State line were inspected.

It was arranged that the conservation commission of the State of New York should handle the barrier-zone work in that State south of Washington County and scout-selected areas in the Mohawk Valley, the Catskill region, and Westchester County, and do the necessary work on Long Island. The bureau handled New York State north of Washington County together with the zone area in Vermont, Massachusetts, and Connecticut, as well as the extreme western section of Connecticut.

This program was completed excepting part of the Mohawk and Catskill areas. These areas will be scouted during the next fiscal year. The necessity for this work was empha-

sized by the finding of a well-established colony in Greenwich, Conn., near the New York State line. A small infestation was found in the town of Kingston, N. Y., by the State force. It is thought that these infestations have been exterminated.

Less infestation has been found in the barrier zone than during the previous fiscal year. the insect has been exterminated in some of the colonies, and the quarantine was lifted from this region at the end of the fiscal year. This includes 71 towns in Vermont, 33 in Massachusetts, and 5 in Connecticut. Early in the year the towns of Cheshire and Wallingford, Conn., which adjoin the zone to the eastward, were thoroughly scouted and the quarantine lifted. These towns have been added to the barrier-zone area and with the other zone towns therein will be subject to periodical inspection and patrol.

The plan of work for the next year provides for a thorough inspection of a considerable number of towns within the western limits of the barrier zone, and if no infestation is discovered work in them can be discontinued for several years, after which a final inspection should be made before they are eliminated from the zone. Preliminary work is also planned in some of the towns adjoining the zone to the eastward. This should result in additional protection to the zone and pave the way for a gradual reduction of the infested area in New England.

The gipsy-moth colony found at Henrysburg, Quebec, by the entomologists of the Dominion of Canada in 1924 was thoroughly treated in 1925 and the infestation greatly reduced. Extirpation should be reached this year.

The gipsy-moth colonies on Long Island have been carefully treated by the New York Conservation Commission and should be cleaned up by the end of another year.

#### **FIELD WORK IN NEW JERSEY**

A strip of towns averaging about 10 miles wide just outside the infested area was inspected in New Jersey. One infestation was found in Elizabeth, and it has been exterminated. Another strip just within this border has been very carefully scouted during the present fiscal year. Two infestations were found, one in Readington and the other in Warren Township. They have been carefully treated and the areas and their surroundings thoroughly sprayed, fish oil

being added as a binder to the arsenical. The central part of the infested region has also been given attention and much spray has been applied, especially on the wooded ridges north of Somerville and Bound Brook.

Light sprayer trucks built last year were operated very successfully this year under varying conditions and demonstrated their usefulness when pressures not exceeding 400 pounds were needed. In order to obviate the delays and loss of time occasioned by the necessity of hauling water in cases where a truck can not be set at the water supply, several small portable triplex pumps driven by a small gasoline engine were obtained. They were mounted on skids and could be easily set up at the water supply. These pumps were used for filling the tanks on the sprayers. They can fill a 400-gallon tank in about 15 minutes by pumping through a 2,000-foot hose line if the water does not have to be forced up too great an elevation. Much time was saved and a greater volume of spraying was made possible by using these pumps.

#### QUARANTINE AND INSPECTION

During the year there has been an increase in the number of certificates and permits issued, the total being 147,694 as against 121,410 for the previous year. The number of egg clusters of the gipsy moth found on shipments was more than 50 per cent less than the year before. Thorough inspection and treatment were enforced before shipments were allowed to move.

Heavy shipments of Christmas trees and greens were forwarded late in the fall and most of the scouting force in New England had to be detailed to that work. Each tree was examined individually and over 100 inspectors were used. The total shipments aggregated 1,033 car lots, 1,018 small lots, and 169 auto-truck shipments. This was about 12 per cent more than the shipments of the previous year. They were consigned to 33 States and the District of Columbia.

#### FIELD AND LABORATORY RESEARCH

The European work was rearranged during the winter and provision was made to place two experts in eastern European countries to study gipsy-moth conditions and investigate the biology of some of the parasites of the gipsy moth about which essential information is lacking. Another ex-

pert made a survey of gipsy-moth conditions in Spain, Portugal, and northern Africa and then proceeded to Hungary, Poland, and Czechoslovakia, where intensive collecting was done to procure parasites for shipment to the Melrose Highlands laboratory. Over 125,000 specimens, most of them in the form of tachinid puparia, were received in 1926.

Methods of packing and shipping have been improved so that the mortality has been greatly reduced as compared with previous years.

Some heavy gipsy-moth infestations accompanied with severe defoliation have been found in these countries, particularly in Hungary, and the data collected are likely to have an important bearing on what may be expected in the United States in the control of the gipsy moth by certain imported parasites.

Colonization of parasites from the Melrose Highlands laboratory has been continued. Over 3,500,000 specimens of all species have been liberated. Most of these were placed in sparsely infested areas in the New England States, a few were sent to New Jersey, and some of the species recently imported were colonized in the badly infested territory on Cape Cod, Mass. Several shipments of *Schedius kuvanae* How., one of the imported egg parasites of the gipsy moth, were sent to Spain and northern Africa to assist in abating the gipsy-moth menace in those countries. The aggregate parasitism in the United States by all species has ranged slightly higher than last year when parasitism reached the lowest level recorded for a series of years.

Field-spraying experiments were conducted in the town of Sandwich, Mass., to test the effect of treatment with arsenate of lead when used at various quantities per acre, with and without fish oil as an adhesive. These tests were checked by the use of small field plots. Most of the trees in the plots were protected from defoliation, whereas contiguous woodland covering hundreds of acres was completely defoliated.

A series of experiments were also conducted in Sandwich, Barnstable, and Falmouth, Mass., to test the utility of an airplane for dusting woodland. Several plots averaging about 25 acres in area were selected in the midst of heavily infested woodland. Such factors as high wind velocity, heavy fog, and other atmospheric conditions greatly retarded the progress of the work. The results were more

satisfactory than any that have been attempted heretofore by this division and a mass of valuable data has been obtained bearing on this method of applying insecticides, although we have not yet formed a final judgment as to the practicability of the method.

### PRESENT CONDITIONS

The brown-tail moth is somewhat more abundant than last year, particularly in southwestern Maine and southeastern New Hampshire. Parasitism averages slightly less.

A hurried survey of the area infested with the gipsy moth indicates that there has been a marked increase in abundance throughout the eastern part of the territory. Defoliation has been noticeable and more or less continuous in eastern Massachusetts both north and south of Boston. Most of the trees in this territory except on Cape Cod showed little trace of defoliation last year. A number of isolated areas, some large and others small, have been reported in widely scattered places, viz., Thompson, Conn.; Deerfield, Mass.; Springfield, Vt.; and Concord, N. H.

The conditions on Cape Cod are far more serious than last year. Large areas of woodland were defoliated before the caterpillars became half grown. Frequently the tender bark of the twigs was eaten and millions of the hungry caterpillars perished from starvation. This condition prevailed over thousands of acres of woodland extending in many localities as far as the eye could reach. The best estimate that is available at present indicates that 47,000 acres were completely defoliated and 11,000 acres partially defoliated on Cape Cod this year.

Present conditions indicate that there will be heavy defoliation in the eastern part of the infested area next summer. Should the insect increase as rapidly in the next few years west of the Connecticut River, the difficulty of keeping the barrier zone free from infestation will be greatly increased.

### CEREAL AND FORAGE INSECT INVESTIGATIONS

W. H. Larrimer has been in charge of the work of this section of the bureau.

#### EUROPEAN CORN BORER

The situation as regards the European corn borer has not changed very importantly since my last report. The

advance of the insect toward the Corn Belt on the extreme western border of the infested area was comparatively slight during the year except in the "thumb" section of Michigan. Here the area more than doubled in extent, probably by flight of the moths from the near-by intense infestation in Ontario, Canada. In western New York and Pennsylvania, however, there occurred a very great increase in area of infestation, the eastern border of which reached well into the "finger-lake" region of New York and as far east as Tioga and Lycoming Counties in Pennsylvania.

Serious injury did not occur to the American crop during the year, but on the Canadian side of Lake Erie immediately opposite Detroit and Toledo an area of at least 400 square miles of excellent cornland suffered a complete loss. This occurrence naturally aroused intense alarm on the part of American growers and agricultural officials.

In the fall of 1925 a general conference of American and Canadian agricultural officials, experiment-station directors, agronomists, and entomologists was held at Windsor, Ontario, to discuss the problem of corn-borer control from an international standpoint. This discussion resulted in a crystallization of opinion as to the necessity for strenuous and immediate action. The conference appointed a committee consisting of influential agriculturists and experiment-station directors of important corn States to act in a general advisory capacity and to urge concerted action by every means possible.

The work of introducing the natural parasitic enemies of the corn borer from Europe has proceeded most satisfactorily. In addition to the parasites formerly reported as established, three additional species, making five in all, may now be considered as having become established. Several new and promising parasites have been discovered by the bureau's investigators in Italy and France.

The States of Michigan, Ohio, and Pennsylvania have promulgated compulsory clean-up regulations and favorable results are becoming apparent.

Among the most important and promising recent results of the bureau's co-operative investigations has been the development of agricultural machinery to meet, in an economical manner, the needs of the corn-borer clean-up requirements. It has been amply demonstrated, both in Europe and in this country, that the control of this pest depends largely, if not principally,



upon the manner of disposal of the cornstalks and cobs. To combat the insect in its winter quarters it is necessary to destroy or ensile the entire stalk of the plant. It has been the aim of those engaged in the investigation of machinery for this purpose to originate a device which will cut the corn at the ground line and which can be attached at reasonable cost to the existing corn-harvesting machinery. This end has now been achieved largely through the efforts of L. H. Worthley, in charge of the bureau's control work, with the active and whole-hearted cooperation of the department of agricultural engineering of the Ohio State University. The large-scale manufacturers of farm machinery have adopted the device and are placing it on the market for use this year. In addition there has been brought to a high state of development machinery which it is believed will successfully pick and husk the corn and shred the residue for silage or to be returned immediately to the soil, at little if any increase in present harvesting costs. The cooperation accorded not only by the States directly involved but by individual officials of the Corn Belt States has been satisfactory and important. On the whole it is felt that a distinct advance has been made on this problem during the year.

#### ALFALFA WEEVIL

The principal events with regard to the alfalfa weevil have been the extension of the weevil territory into eastern Wyoming; the scouting of the weevil territory in southern Utah, southern California, northeastern Oregon, southeastern Washington, southern Montana, and eastern Nevada; a severe attack of the weevil in western Nevada and northern Utah; a suspended attack in western Idaho; some encouraging dusting experiments with land machines in Nevada and with airplanes in Utah; tentative studies of temperature control of the insect; the continued introduction and study of European parasites of the weevil; and the preparation of a Farmers' Bulletin and a motion-picture film describing the life-history stages and control of this insect.

The extension of the weevil territory to eastern Wyoming marks the entrance of the alfalfa weevil into the Mississippi Valley and also into a climate decidedly different from that in which it has heretofore been studied, the principal differences be-

ing the coolness of the winters and the concentration of rainfall during the spring and summer months instead of in the fall and winter, as in the regions west of the Rocky Mountains. The territory where the weevil occurs in eastern Wyoming is practically continuous with the alfalfa-growing areas in Nebraska and Kansas.

Our knowledge of the geographical distribution of the alfalfa weevil has been brought nearly up to date. The territory has been outlined in southern Utah, southern California, eastern Oregon, southeastern Washington, southern Montana, and eastern Nevada, and the work is at present being continued in western Idaho, northern California, and central Colorado. No important extensions of the weevil territory have been found since July, 1925, but there has been a slight general advance all around the border.

The most serious attack of the alfalfa weevil since 1921 has occurred in western Nevada and northern Utah. In both localities the damage has been general, very few fields escaping serious damage to the first crop, although the weather was generally favorable for early cutting. A similar outbreak began in western Idaho, but ended prematurely. An outbreak which was anticipated in central Utah, because of the extremely warm spring, did not develop.

The suspended and incomplete attacks of the pest in Idaho and central Utah are perhaps the most important events of this whole year, as they throw light upon the control of the weevil by climatic influences. The interruption of the attack in Idaho is closely correlated with a cold, wet week which occurred at the height of this oviposition period (for that locality) but too early to have a similar effect in Nevada and Utah. The absence of damage in central Utah seems to be due to the very early maturity of the crop itself, but as we had no observer stationed there our facts are too meager to justify a theory.

Parasite studies have been divided between a survey of parasite abundance in the regions surrounding Salt Lake City and Heber, Utah, and the rearing and liberation of parasites collected by the corn-borer laboratory in Europe. Dissection of larvæ from alfalfa fields during the latter half of 1925 and early 1926 shows relatively few parasitized by *Bathyplectes curculionis* Thoms. in the Salt Lake Valley, increasing in certain instances in 1926, and large numbers parasitized



at Heber. Mymarids, as yet undetermined, have been reared from eggs collected in the fields at Salt Lake City, and the same or a related species from eggs of the clover leaf weevil. Cocoons of *Microbracon tenuiceps* Mues., parasitic upon larvæ of the lesser clover leaf weevil, have been reared artificially upon alfalfa weevil larvæ.

A motion-picture film has been prepared for the use of the extension service, largely on the initiative of the director of extension of the University of Nevada. Pictures of weevil work, of life history, and of control and quarantine measures, made in the field, were rounded out by animated cartoons made by the motion picture laboratory, and are in use. Additional pictures of adults and larvæ and of airplane dusting have just been completed and are to be included in the film.

#### HESSIAN FLY

The Hessian-fly investigations have been continued along the lines as previously reported. Infestation data, recorded and interpreted with respect to the time of sowing and climatic conditions, have been obtained for the year from all the principal wheat-growing areas. Biological and ecological studies have progressed well. In general, no widespread serious damage has occurred to wheat because of this pest during the year. This is primarily because of a combination of unfavorable weather conditions and the general observance of control measures. The situation in Kansas continues to be a source of considerable anxiety.

#### CEREAL AND FORAGE INSECTS IN GENERAL

Under the cereal-insect group continuation studies have progressed on such major pests as the jointworms, chinch bug, white grubs, wireworms, the sorghum midge, cutworms, webworms, billbugs, the corn ear worm, and the green bug. Several of these insects were also studied as to their damage to forage crops, and in addition special studies were continued on the alfalfa seed chalcis, grasshoppers, army worms, and lesser clover leaf weevil and other clover weevils. Several technical papers and Farmers' Bulletins dealing with the various phases of the life habits and control of these species have been published and several more are in manuscript for publication.

#### SOUTHWESTERN CORN BORER

This pest continues to hold potential importance and the situation regarding damage by it in New Mexico, eastern Arizona, and western Texas has not changed materially during the year. No funds have been made available to finance a real study of this pest. Such observations as have been possible by workers on other problems confirm our former opinions to the effect that a thoroughgoing investigation should be started just as soon as possible.

#### SUGAR-CANE AND RICE INSECTS

During the fiscal year a study of the control of the sugar-cane mealybug at Cairo, Ga., was completed.

Careful status studies were made of the sugar-cane moth borer in Louisiana, and in cooperation with the Bureau of Agricultural Economics it was estimated that it caused in 1925 a loss of 30 per cent of a full crop. This is the greatest loss from the moth borer since 1916. The publication annually of a cooperative estimate of damage has served to focus attention on the work of this insect as never before.

The tachinid parasite introduced from Cuba several years ago was found to be still present in Louisiana, though in such small numbers as to have no effect on the control of the moth borer. At the request of the Bureau of Plant Industry, and with the cooperation of the Tropical Plant Research Foundation, the same parasite was sent from Cuba and liberated at a field station of the Bureau of Plant Industry in Florida.

Calcium cyanide was tried as a fumigant for seed cane, but without success. It was hoped that hibernating larvæ of the moth borer in the stalks could be killed.

Preliminary experiments in applying dusts to sugar cane with the object of poisoning the moth borer were conducted.

Sodium fluosilicate was found to be very effective against the striped blister beetle when dusted on soy beans. Soy beans were recommended as a rotation crop on rice plantations, but the blister beetle was such a serious pest that this recommendation was not adopted. The discovery of the use of sodium fluosilicate as a control measure is bringing about a general planting of soy beans, which will be of great benefit to the Louisiana rice planters. Two manuscripts

were written on this work. The life history of the striped blister beetle is being carefully studied.

By a number of large-scale tests the exact damage to rice from the rice water weevil is being worked out. Information is being accumulated on the various rice insects, and a comprehensive manuscript is in preparation.

### **STORED - PRODUCT INSECT INVESTIGATIONS**

E. A. Back has continued in charge of this section of the work of the bureau.

#### **BEAN WEEVILS**

The investigation of weevils attacking beans and cowpeas has been continued along the same lines as last year. The results of the practical field control obtained this year have formed an excellent sequel to the field work on bean plantations of last year. The data have so impressed the California State Department of Agriculture and the industrial bean growers in California that heartiest cooperation has been established. The collection for examination at time of harvest of samples of beans from various plantations has made it possible for the bureau officials to predict conditions on various plantations with certainty.

#### **GRAIN INSECTS**

During the year many new scientific data have been published in bulletin form as a result of the work of the bureau on the biology of grain pests. Other publications are under way. The work in Georgia on the rice or black weevil has continued along the same general lines. These studies strengthen still more the idea that the rice weevil can best be controlled by intelligent control in storage by fumigation. On isolated farms where no control has been instituted for several years field infestations at time of harvest in certain instances ran as high as 98 per cent of all ears of corn. In other fields well isolated by woodland, or near farm buildings in which the stored corn was intelligently fumigated, field infestations were less than 1 per cent of the total ears.

#### **GRAIN FUMIGANTS**

Cooperative work with the Bureau of Chemistry has been continued with the object of finding a safe, cheap fumigant that will be as effective as carbon disulphide for the treatment

of infested grain. Many new compounds have been tested and several of the more promising have been selected for large-scale tests.

#### **ANGOUMOIS GRAIN MOTH**

Our work has thrown much light upon the biology of this great pest. Of special importance to the farmer has been the information obtained as to the stage of growth of the wheat plant when infestation may occur, the importance of control in storage to prevent field infestation, and the premium placed on intelligent control.

#### **DRIED-FRUIT INSECTS**

The support given last year to the bureau's investigations of insects destroying dried fruits and vegetables, by the California Dried Fruit Association, has been continued this year. A thousand-dollar donation by the association has made it possible to give more attention to the work. Aside from the studies of the biology of the insects involved, large-scale practical experiments have been under way to determine the value of metal barriers and oiling of the processed fruit, particularly raisins, in preventing infestation. This work is nearly completed. Other fruits, such as peaches and prunes, will soon receive attention.

#### **MOTH-PROOFING SOLUTIONS**

Although the results so far are not such as to indicate that complete and permanent immunity against fabric pests can be obtained by the use of moth-proofing solutions, certain solutions have been proven of decided protective value. Whether brushes and furs can be satisfactorily treated is yet to be determined. The value of epsom salts alone as a moth-proofing agent appears to have been disproved by the work of the year.

#### **FURNITURE PESTS**

The continued vogue for overstuffed furniture has greatly increased the demands upon the bureau for information regarding furniture pests, and these insects have been studied during the year. Two short articles have been published and a well illustrated bulletin is in preparation. This work has received the cooperation of the American Furniture Warehousemen's Association and of the National Association of Upholstered Furniture Manufacturers.

## TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS

A. C. Baker is now in charge of this work.

### FRUIT FLIES IN HAWAII

Investigations of fruit flies in Hawaii, including inspection and certification work in cooperation with the Federal Horticultural Board, have been continued. The total of 289,796 packages inspected during the year is an increase of 25,733 over 1925 and 52,141 over 1924. Baggage inspection also increased by 275 trunks over 1925.

Studies on the susceptibility of cooking bananas proved them possible carriers of the fruit fly and as a result no modification of the quarantine was recommended to the board. An investigation of the susceptibility of onions was made at the request of the board and this indicated that the onion is highly resistant to infestation by the fly. Avocado studies have been continued but sufficient data are not available to permit recommendation in regard to the quarantine regulations touching Guatemala varieties. Two successful shipments of 2,202 fruit-fly puparia parasitized by *Opius humilis* Silv. were made to the department of agriculture, Paget, East Burma, and an unsuccessful attempt was made to ship 1,294 puparia in cold storage to Palestine.

### FRUIT FLIES IN THE CANAL ZONE

Studies on tropical-fruit insects have been continued in the Canal Zone and special attention given to investigations of fruit flies. Ant control with calcium-cyanide dust has been further studied, and as a result the Republic of Panama has adopted this fumigant and started an intensive campaign. Tests of various wood treatments against termites are being continued in cooperation with the division of forest insect investigations, and a test building is now being erected in Barro Colorado Island. Time has been given to the rubber, abaca, and chaulmoogra introductions.

### CITRUS THRIPS

The infestation of the citrus thrips has been more pronounced this year than any season since 1922, and efforts toward a satisfactory control have been continued, 66 acres being now under treatment. The biological work on the thrips has been practically completed.

## FLORIDA CITRUS INSECTS

The work in Florida during the year has been largely confined to a study of the citrus aphid and a study of oil sprays. The aphid work has consisted of control experiments and a study of the factors giving rise to the recent epidemic. The conditions are now fairly well charted and it is expected that sufficient information will be available to permit prediction in future cases. The influence of climatic factors on the rise and fall of the aphid populations and their counter populations of predatory enemies, parasites, disease organisms, etc., has been studied in detail under natural conditions by quantitative methods. Many interesting successions have been discovered which support predictions made on theoretical grounds. Since an accurate knowledge of the influence of climatic factors on the various biological agencies involved in an epidemic is essential for prediction, we have carried the leads from natural conditions into the laboratory. We have therefore equipped the laboratory with an outfit in which temperature, humidity, light, and air movement can be controlled.

The work on oil sprays has included experiments with oils, oil emulsions, and emulsifiers. This has touched on the so-called quick-separating emulsion as compared with good soap emulsions, the effect of oil sprays on the size and maturity of the fruit, the relation of temperature and mechanical agitation to the size of the globules, and the preservation of emulsions with emulsifiers or stabilizers.

### GREENHOUSE INSECTS

Owing to the increasing importance of the bulb industry, particularly since the placing of the quarantine on narcissus bulbs, we have been forced to curtail some of the greenhouse work to give attention to bulb pests. A survey of the Pacific coast bulb fields was made during June and July, 1925, a full report of which was given at the bulb conference last November. The narcissus fly was found to be a primary pest in some of the west-coast plantings. An examination of recent commercial plantings on the east coast during April, 1926, indicated that flies had not yet gained a foothold, excepting in some of the Virginia plantings.

Biological experiments and certain control experiments on bulb flies have

been conducted in Washington. A series of tests with carbon disulphide at normal atmospheric pressures showed that the time factor necessary for sufficient vaporization resulted in severely injured bulbs.

Fumigation under vacuum has been tried in a preliminary way with various dosages and exposures. Flies and mites were controlled, but the treatments resulted in injury to the bulbs.

The work in California has included biological studies of bulb pests and studies on hot-water treatment. The tests made have substantiated the statement that immersion at 110° F. for three hours is fatal to the flies and mite.

Experiments in fumigation with hydrocyanic acid gas, in cooperation with the Bureau of Chemistry, have been conducted in Washington. The primary object here has been the correlation of the resultant mortalities of certain greenhouse insects with the comparative rates of evolution of gas generated from equivalent quantities of cyanogen, whether calcium cyanide, sodium cyanide, or liquid hydrocyanic acid is used as the source. Observations on the possible variation in diffusion or stratification of the gases at various elevations are being made and the influence of temperature and humidity considered.

#### CAMPBOR SCALE

Work has been continued with the camphor scale and other scales. During the latter part of the year time has been given to bringing together in the raw form all the data gathered since the inception of the work. A careful analysis of these is now being made, with a view toward determining the conclusions possible and the future needs of the problem.

#### TRUCK-CROP INSECT INVESTIGATIONS

Work on the project of vegetable and truck-crop insects has been continued under the direction of J. E. Graf.

#### SWEET-POTATO WEEVIL

Additional progress has been made on the eradication of the sweet-potato weevil in the States of Alabama and Mississippi and in two of the three eradication projects in Florida. In Mississippi there was a division of the work, the State plant board taking over the eradication campaign in the counties of Harrison and Jackson and the bureau limiting its activities to

Pearl River and Hancock Counties. Clean-culture methods were conducted by inspectors and agents and clean planting stock furnished to the farmers of all properties known or believed to be infested. At the close of the year 10 properties were known to be infested in Pearl River County, 9 of these being new infestations and 1 a hold-over. In Hancock County 21 properties were known to be infested at the close of the year, 9 of these being new infestations.

In Alabama the work followed closely the methods used in Mississippi, except that clean planting stock was not supplied to the growers. In Baldwin County the considerable increase in the number of infestations was traced to a new infestation center in which many of the wild host plants were infested. Additional assistance was furnished by the State of Alabama and Baldwin County, and as no potatoes were grown on the infested properties it is now believed that the situation is well in hand.

In the Baker-Charlton eradication project in Florida every farm was inspected twice and some of the more suspicious properties several times. All of the stored potatoes in the previously infested area were examined and no weevils were found. This was most encouraging, since the Baker-Charlton area was the first eradication zone to be set aside by the Bureau of Entomology. In the Lilly eradication project in southern Florida inspections during the fall of 1925 and spring of 1926 showed all farms to be apparently free of the weevil. This project, although small, is of great importance since sweet-potato culture in the southern part of the State is on a different plan, most of the young plants for the fields coming from "stand-over" plant beds in which the infestation is carried readily from year to year. The Seffner eradication project in the vicinity of Tampa has not given good eradication results, most of the farms again showing infestation by the weevil during the present year, though in smaller numbers.

#### MEXICAN BEAN BEETLE

The Mexican bean beetle continued its spread in the East, invading many new counties in Tennessee, Kentucky, and Indiana along the western edge of the infested area, and in Pennsylvania, West Virginia, Virginia, and North Carolina along the eastern edge. Beans suffered severe injury in the more hilly sections of Tennessee,



Kentucky, West Virginia, Virginia, and Ohio.

Tests with new insecticides including a large series of fluorine compounds were made during the year. Of the compounds tested, sodium fluoride, barium fluoride, sodium silicofluoride, and barium silicofluoride were the most toxic. Tests with sodium silicofluoride indicate that this is a very promising insecticide for the bean beetle.

Studies in New Mexico showed that the successful hibernation of the bean beetle is confined to the yellow-pine (*Pinus ponderosa*) region where oak trees are associated. During the last two seasons in the area above this region, 15,500 beetles perished in hibernation without a single case of survival. Below this region in the pinyon belt, only 30 beetles emerged from a cage containing 2,500 insects. In the short-grass region of the Estancia Valley only 4 beetles survived out of 10,487 used in the hibernation studies. Tests conducted with marked beetles furnished additional evidence that the insect follows prevailing winds and flies either up or down canyons, which are the principal migration paths.

#### PEA APHID

By trapping migrating pea aphids on sticky screens it has been found that in Wisconsin there is usually a heavy migration of the insect about July 10, and that this migration complicates control methods, for it comes at a time when most of the pea vines are in pod. Owing to the unusual climatic conditions the pea vines made a heavy growth, and as the infestation appeared relatively late it was necessary to sweep the fields at the time the vines were in pod and unusually large. Considerable damage was done to the vigorous vines by the machine. In most cases the size of the yield from fields swept with the aphidozer was less than that of untreated plots, but in every case the peas from the swept areas were of higher grade. In several instances this difference in grade resulted in a higher return per acre from swept plots than from adjacent unswept plots, despite the fact that the total yield in unswept plots was higher.

In California tests of nicotine dust for the control of the pea aphid were continued. Homemade dusts prepared with a self-mixing duster were used, and in one field of market peas three applications of nicotine dust were

made at a cost of \$56.80 per acre, which successfully controlled the pea aphid, and resulted in a net profit of \$80 per acre over untreated fields. A reduction in the number of applications did not give such good control of the insect, but in one field a single application costing \$14.65 per acre resulted in a net profit of \$17.12 per acre over undusted fields.

#### TWELVE-SPOTTED CUCUMBER BEETLE

It was found that the situations selected for oviposition by the twelve-spotted cucumber beetle are influenced by the quantity of moisture in the soil and its physical condition, a soil with cultivated or roughened surface being preferred if sufficient moisture is present.

#### POTATO AND TOMATO INSECTS

##### SEED-CORN MAGGOT

Field and laboratory studies have been conducted on the influence of weather conditions and other factors responsible for infestation by the seed-corn maggot. It has been found that the eggs of the adult fly are not normally deposited on freshly cut pieces of seed potato, even though these are left exposed in the field for several hours. The young maggots do not feed on healthy pieces of potato seed, but if decay is present the maggots enter these spots and develop without difficulty. It appears from the work to date that the maggot attack normally follows seed-potato injury or decay. It has been found that planting methods which tend to preserve the seed and prevent rotting or burning throughout the germination period will lessen injury by this insect.

##### TURNIP OR AUSTRALIAN TOMATO WEEVIL

Work was continued on the turnip or Australian tomato weevil at the laboratory in southern Mississippi. This insect has continued to spread, and is now found in 24 counties in southern Mississippi, 8 parishes in Louisiana, 7 counties in Alabama, and 2 counties in Florida. It has recently been found in the vicinity of Santa Cruz, Calif., attacking carrots. It shows very little activity during mid-summer, and apparently the principal spread takes place in the fall, winter, and early spring. Tests with various arsenicals in both the spray and dust forms have given good control.



## TOMATO FRUIT WORMS

It was found in Louisiana that practically all of the eggs of the tomato fruit worm were found on the terminal growths, the taller plants apparently being preferred for oviposition. If this is a normal habit of the insect, it will aid in disclosing serious infestations in sufficient time to permit the application of remedies. In North Carolina good control of the tomato fruit worm was obtained by the use of the mole-cricket bait, modified by the addition of a small quantity of molasses. This bait was scattered over the plant, and as the worms migrated from fruit to fruit during the course of their development many of them came in contact with and consumed the baits.

## POTATO-LEAF HOPPER

The work of the past year on the potato-leaf hopper, conducted cooperatively with the Wisconsin Experiment Station, has borne out earlier experimental results in showing that the use of Bordeaux mixture gives higher potato yields than that of the copper-lime dust. It seems to be the consensus of opinion among the growers, however, that even though spraying is superior to dusting, the greater ease and quickness of dusting greatly outweigh the advantages of spraying.

## GENERAL VEGETABLE INSECTS

## CULTIVATED LAND WIREWORMS

Work on the cultivated land wireworms has been continued in Washington in cooperation with the division of cereal and forage insect investigations, and in California. In order to reduce the cost of soil fumigation with hydrocyanic-acid gas, it has been necessary to concentrate the wireworms by baits, and later to treat the baited rows with the calcium cyanide, from which the gas is evolved. Such baits as peas, beans, and corn attract the wireworms readily. Under satisfactory soil and temperature conditions, a large proportion of the wireworms can be attracted to baited rows from 2 to 6 feet apart, in from 2 to 10 days, the actual percentage of worms attracted decreasing as the width of the rows increases.

It appears that about 99 per cent of the wireworms were attracted to rows 3 feet apart. Under average

conditions, 6 pounds of calcium cyanide to 1,000 feet of row is considered an efficient dosage. Biological studies are under way at the Washington laboratory in an attempt to discover some of the factors responsible for field infestation.

## PORTO RICO MOLE CRICKET

Poisoned baits have given the most satisfactory and economical control of the mole cricket under both cultivated and sod-land conditions. The principal experiments of the past season were conducted on the golf course at Brunswick, Ga., which afforded entirely different conditions from those found in cultivated lands. The poisoned bait gave excellent control and the infestation was reduced to the point where practically no injury could be observed during the fall and winter. By incorporating molasses at the mill, the composition of the bait has been changed slightly to obviate fermentation. The improved bait appears to have better lasting qualities, and does not require the addition of water before application.

## PEPPER WEEVIL

During the winter of 1924-25, adults of the pepper weevil hibernated in southern California, but owing to the high temperatures which occurred during the winter, active adults were found throughout the winter and spring. Cage tests with both calcium arsenate and sodium silicofluoride have given promising results in controlling the weevil, and under field conditions the use of these materials practically doubled the yield of sound peppers.

## CELERY LEAF TYER

Work on the celery leaf tyer in cooperation with the Florida State Plant Board has been undertaken in Florida. A careful experiment in determining the arsenical residue found on the celery plants at harvest time following treatments with various arsenicals was conducted with the Bureau of Chemistry. A study of the natural enemies of this insect in Florida and their effect on its seasonal abundance is now under way.

## SUGAR-BEET INSECTS

In cooperation with the experiment stations of several of the Northwestern States an intensive study of the desert

breeding grounds of the sugar-beet leaf hopper was undertaken, the principal object being to discover the stimulus responsible for the migration of the insect from its desert breeding grounds to cultivated beet fields. It has been discovered that the leaf hopper does not migrate from the desert breeding ground if suitable food is available in its desert environment, and the osmotic concentration of the sap of its food plants has been shown to give an index of the suitability of such plants as food. A number of stations for the study of the weather have been established over the desert areas adjoining the beet regions in southern Idaho and the information thus gained has proved of great value in connection with studies on the behavior of the insects under desert conditions. Careful laboratory work has developed a technique for feeding homopterous insects artificially, and it is expected that by the use of this method it will be possible to determine several troublesome points in connection with the transmission of plant diseases by insects.

### BERRY INSECTS

#### STRAWBERRY WEEVIL

Sulphur-arsenical dusts gave good weevil control but burned the tender strawberry foliage in some tests. No insecticidal injury was noticeable to either bloom or fruit. Bordeaux-arsenical dust gave about as good control of the weevil as the sulphur-arsenical dust and produced no injury to the plant. It was found that the dust was more effective when applied to dry plants than when applied to wet plants, since apparently a better covering is obtained when dry plants are treated. These remedies for the weevil were used by growers on approximately 160 acres at a total cost for material of about \$800, resulting in an estimated saving to the growers of about \$24,000.

#### BERRY-MOSAIC TRANSMISSION

In cooperation with the Bureau of Plant Industry, investigations were inaugurated last season leading to the determination of the status of the various bramble-infesting insects in the transmission of three serious and obscure filterable-virus diseases affecting chiefly the red and black raspberries in the United States, that is, the red raspberry mosaic, the streak disease, and the mild mosaic.

Pure cultures of aphids free from infection by these diseases have been established and a pedigreed collection of infected plants harboring the viruses of these diseases is available for the production of virulent aphids.

### PHYSIOLOGICAL INVESTIGATIONS

In cooperation with the University of Pennsylvania a series of quantitative studies was undertaken on the effect of arsenicals on insects. This work was necessary in order to make available a more accurate measure of the toxicity of the various poisons to the various groups of insects. It has been found that different arsenicals vary in their effect on insects, and also that these arsenicals affect differently young and old insects. Apparently trivalent arsenic as it occurs in the arsenical is more toxic to insects than the pentavalent form.

### STUDIES OF ARSENICAL RESIDUES

In addition to the work on celery in Florida, studies of the arsenical residues on other vegetables are being conducted in cooperation with the Bureau of Chemistry, and it is hoped that as a result of these investigations it will be possible to make spraying recommendations which will be entirely safe from the arsenical-residue standpoint, and thus assure the grower that his products, if protected from insects, will be entirely safe for market.

### INSECTS AFFECTING TOBACCO

Wireworms continue to be an important pest of tobacco in the Burley region about Lexington, Ky., an average of more than 50 per cent of the plants being attacked where tobacco follows sod. Investigations made during the year indicate that poisoned baits are much more effective for these insects when applied to freshly harrowed ground than when applied to a crusted soil. Under the favorable conditions as described above, a reduction of more than 90 per cent of the wireworm infestation has been achieved.

The tobacco Crambus (*Crambus caliginosellus* Clem.) continues to be a pest of major importance in the dark-tobacco belt of western Virginia. In years of severity the loss may amount to from 15 to 20 per cent of the crop, totaling more than \$1,500,000 for the belt. In years of lighter infestations the loss amounts to about 5 per cent of the crop, totaling around \$350,000.

This loss is brought about by infestations of early settings, necessitating one or more replantings, the first of which is frequently almost a complete resetting. A great decrease in yield and quality results. At the Virginia tobacco experiment stations, at Chat-ham and Appomattox, the loss has been estimated to amount to about 14 per cent annually. The experiments at Appomattox during the planting seasons of 1925 and 1926 resulted in a reduction of from 50 to 65 per cent of the crambid injury by one application of poisoned bait, at a cost of about 1 per cent of the crop value.

Years ago a method was devised for the control of tobacco hornworms and the remedy made available to the public through bulletins. During the present fiscal year data have been collected which suggest the possibility of an entirely new method of control for these pests. Amyl salicylate has been found to be a powerful attractant to the hornworm moth and experiments are under way to determine the feasibility of using this chemical to attract the moths to a poisoned bait before they have deposited their eggs upon the tobacco.

## INVESTIGATIONS OF INSECTS AFFECTING COTTON

This work has been carried on under the immediate direction of B. R. Coad.

### COTTON-BOLL WEEVIL

The extreme drought of 1924 extended through the cotton-growing season of 1925 and resulted in a very light infestation of weevils in most of the Cotton Belt during 1925. For this reason much of the work dealt with a check-up of various control measures under conditions of comparatively light damage as far as the boll weevil was concerned. Commercial use of poison was decidedly limited by the shortage of weevil infestation and instead of increasing in extent as has been the case each season for a number of years back, the area treated was apparently more or less the same as that of the preceding season.

In connection with boll-weevil control, special attention was devoted to a study of the width of "swath" possible with various types of dusting machinery in the effort to increase this wherever feasible to permit greater acreage capacity for the machines. Dust applications were made under all kinds of conditions with representative series of machines varying

from the smallest to the largest, and the amount of material adhering to the cotton plants as well as the width of spread was determined. This was then checked against the width of the weevil-control area and also the area in which cotton-leaf-worm control was accomplished. This work is not yet completed but evidently it is going to be possible to recommend certain of the newer types of machinery for wider swaths than were considered possible in the past. For several years there has been considerable public interest in the so-called cloud-drift method of dusting, under which the machines blow out a large quantity of dust and this is allowed to drift down wind across the field. The tests so far are rather discouraging, indicating that there is little likelihood that this method will be safe beyond a narrow limit. The relationship between various types of dust and the results of these tests has been given special attention.

In conjunction with the foregoing studies, special observations have been made on the relation between the adhesion of poison and varietal characteristics of cotton plants. For example, certain varieties are very hairy, whereas others are practically hairless.

The weevil-hibernation studies mentioned in preceding reports have been continued on an even larger scale. In the fall of 1925 hibernation cages were installed at 16 points scattered throughout the South from Texas to North Carolina. These tests were conducted, as a rule, by the State experiment stations and in the spring the weevil-emergence results were reported to the Tallulah office at bi-weekly intervals. Before the emergence actually started, a series of mass examinations were made throughout the South, one for the purpose of determining the number of weevils entering hibernation in the fall, and the other to determine the survival at the end of the winter. All of this information has been embraced in a series of reports issued at regular intervals. With the completion of emergence in the hibernation cages, these same cooperators inaugurated a series of biweekly reports on general cotton-insect conditions, which are issued in the same manner as the earlier reports.

The investigations on attracting the boll weevil by utilizing constituents of the cotton plant have continued as before and certain dilutions of trimethylamine and ammonia have proved

to be attractive to the weevil in laboratory tests. Field observations are now under way to determine whether or not the attractiveness of these materials can be increased to the point where they can be made of practical use.

The investigations of various types of dusting machinery have shown considerable progress. Commercial airplane dusting in 1925, although somewhat handicapped by lack of full information on the subject, showed the practicability of this method and as a result there are now several commercial airplane-dusting companies operating on a very extensive scale. Evidently several hundred thousand acres of cotton will be dusted in this manner during 1926. The experimental work has dealt largely with improvements in the mechanical devices for distributing the dust as well as improving the technique of dusting.

In the ground-dusting machinery especial attention has been devoted to the development of motor-operated, high air-velocity machines. These machines have the advantage of dusting more rapidly, requiring less dust for an effective covering, and also of being able to operate under adverse atmospheric conditions where the ordinary types can not make a satisfactory application. Several commercial companies are now interested in this new design and some test models built by them are in course of field trial. It is expected that these will be on the market for the season of 1927.

The relation between the exact chemical nature of calcium arsenate and its effectiveness in insect control is being studied very thoroughly. Chemically pure calcium arsenates of the various possible types have been made, and manufacturing conditions influencing their production have been studied. These arsenates have been tested against the weevil and other cotton insects to ascertain their relative values, and their effects on the cotton plant have been studied. It is anticipated that out of this series of studies a calcium arsenate much improved in both chemical and physical qualities can be evolved.

The program of work at the Florence, S. C., cooperative station has now been considerably modified. The experiments on various control methods under Southeastern conditions were carried through a three-year period and have now been closed and the results published. At present the only investigations of the bureau under way at Florence are the intensive

biological studies on the boll weevil. In these especial attention is being devoted to the seasonal occurrence of different generations of weevils as well as the migration habits of the weevil. Evidently information of great importance in practical control methods is to be derived from this series of observations.

#### ARIZONA WILD-COTTON WEEVIL

This insect has assumed greatly increased importance. Some 15,000 acres of cultivated cotton in the Santa Cruz Valley became infested during the past season. The biological investigations that were being conducted at the same time gave further proof of the ability of this weevil to thrive on cultivated cotton. It shows very important differences from the ordinary cotton boll weevil. It is able to withstand much higher temperatures, and hibernation investigations during the past winter showed a survival of approximately 75 per cent as contrasted with a survival of under 5 per cent which is usual for the ordinary boll weevil. The potential importance of this pest in case of introduction in the arid and semiarid areas of cotton production can hardly be overestimated and every effort is being made to prevent such spread if possible. Federal quarantines are now being enforced to prevent movement from the infested area. Intensive scouting is under way to determine the extent of infestation in the cotton fields, and a systematic scouting of the mountain ranges is being conducted to work out the complete distribution of this variety in nature. Special studies are being conducted to determine the feasibility and possible cost of some type of clean-up of the insect in nature as a possible permanent solution of the problem.

#### OTHER COTTON INSECTS

The cotton leaf perforator, which has been known to attack cotton in the arid sections of the West and particularly in the vicinity of the Imperial Valley of California, has been doing increasing damage each year and it was estimated that the damage in the Imperial Valley in 1925 ranged from 15 to 30 per cent of the crop. For this reason, a new station has now been opened at Calexico, Calif., and complete biological and control studies are being conducted to determine the exact extent of injury by this species and the possibility of its control.



The cotton-flea-hopper investigations have been greatly enlarged. Studies for several years at Port Lavaca, Tex., showed clearly the destructive capacity of this pest. Furthermore, in 1925, sporadic outbreaks of this damage were encountered at various places in the Cotton Belt extending as far east as Georgia and South Carolina. For this reason, a summary of all work which has been conducted was prepared during the winter of 1925-26 and an intensive experimental program outlined for the season of 1926. This has been greatly expanded, for in the early spring of 1926 an outbreak of this species developed over almost the entire Cotton Belt, causing rather serious damage. Apparently a fair degree of control can be achieved by the proper use of dusting sulphur, and several circulars giving instructions for such operations have been issued. It has now developed that the damage is apparently due to some form of disease or toxin transmitted by the insect and that, instead of a single species, a number are involved in causing this injury. The various species and host-plant relationships of all of these are under investigation. In Texas it has been found that the horsemint and croton plants are the important alternate hosts, but in other sections new plants are found. For example, in much of the central South the evening primrose becomes an important host plant. The flea-hopper problem is a very serious one and much intensive study will be required for its solution. Investigations are under way to determine the exact nature of the toxin or disease transmitted by the insect and the possibility of at least reducing the damage by indirect control measures such as field and ditch clean-ups.

The cotton leaf worm continues increasingly active and studies on this subject are made each season. Careful watch is maintained for the first occurrence of the worms in the extreme southern portion of the Cotton Belt and the progress of the different generations is then followed so that the farmers can be given due warning of expected invasions. This is proving especially valuable in enabling them to locate poisoning material in advance of the actual need. Special studies are being conducted to determine the relation between wind conditions and the direction of migration of the leaf-worm moths. This is accomplished by a series of releases of hydrogen-filled balloons.

The problem of weevil and leaf-worm control, of course, has many interrelationships and special studies have been made for the purpose of working out the most profitable dusting program in dealing with a situation in which both insects are involved.

The interrelationship between boll-weevil control and cotton-louse damage is an important subject of investigation. It has been found that the increase in louse infestation following calcium-arsenate dusting is a reaction to the mechanical killing of certain parasites and occurs only when these particular species of parasites are the dominant control factor. It has been found that it requires about three applications of calcium arsenate, made at short intervals during the absence of rain, to induce an injurious degree of louse infestation. At the same time, a method has now been evolved by which 2 per cent of nicotine can be added to calcium arsenate and applied for louse control with very satisfactory results, provided the application is made at a time when the air will remain practically calm for at least 30 minutes after the application is completed.

Observations on other cotton insects, such as the bollworm, grasshoppers, and various caterpillars, have been continued as usual, and farmers have been given the best advice possible for meeting local outbreaks as they occur. Such additional information as is possible is gained in each case.

#### INVESTIGATIONS OF INSECTS AFFECTING THE HEALTH OF MAN

The bureau acts as a center for information regarding medical entomology and has a very large correspondence with medical men, sanitarians, and the medical officers of the Army and Navy, and is in close cooperation on such subjects with the United States Public Health Service. The principal research work of the year has been devoted to mosquitoes and malaria and upon the skin malady known in portions of the South as "creeping eruption."

#### MALARIA AND MOSQUITOES

Investigations were continued at Mound, La., on the biology of malaria mosquitoes and methods of control in the alluvial lands of the Mississippi Delta, under the direction of W. V. King. Department Circular No. 367 was issued giving the results of pre-



liminary work in the use of airplanes as a means of distributing mosquito larvicides over large swamp areas, and a short supplementary report was issued later providing information as to the cost of such operations and their practical application.

The cooperative work with the department of immunology of the Johns Hopkins School of Hygiene and Public Health on the identification of the blood meals of mosquitoes, as a means of determining the host relationships and preferences of the various species, was brought to a close and the results of the large number of precipitin tests performed have been partially analyzed in preparation for a final report on the completed studies.

A report was published covering recent observations on the rate of emergence of adult *Anopheles* from natural breeding places and showing the relation of larval abundance to the number of adults produced per unit of area. New data were also presented showing the proportion of sexes emerging under natural conditions.

For several years past systematic observations have been made on the relative importance of the various types of breeding places in the production of *Anopheles* and the conditions favorable or unfavorable for their development. This has necessarily included a study of the larger aquatic vegetation and its relation to mosquito-breeding areas. These studies have been extended during the year by an investigation of the smaller aquatic life associated with *Anopheles* larvæ. This is done to determine the food requirements of the larvæ and will include studies of the abundance and seasonal distribution of the various plankton groups, especially the algæ, and their correlation with larval incidence.

The very unusual and prolonged drought of last summer interrupted the tests of airplanes in the treatment of breeding areas with Paris green. In the early part of the season, however, considerable additional information was acquired as to the practical application of this method, from a number of tests made on a prolific breeding area of about 800 acres. The effect of the drought in destroying aquatic vegetation was such that even after the swamps again became filled with water during the winter breeding has been very light and scattered during the 1926 season and the dusting experiments have not been resumed.

Laboratory work on larvicides has been continued and a large series of arsenical and other compounds, including certain proprietary products, have been tested out comparatively. The peculiar variation in susceptibility of *Anopheles* larvæ to poisoning with different arsenicals has brought up an important chemical problem as to the nature of the toxic effect of such products as Paris green, to which they are highly susceptible. Some studies have been made as a preliminary to further investigations.

Several conferences were held with members of the Public Health Service in regard to the feasibility of employing airplanes and Paris green in the control of *Anopheles* in various areas in the Southern States impounded for hydroelectric purposes. Another conference was held with members of this service and with the medical and other officers of the Marine Corps at Quantico, Va., with regard to mosquito control at this post. The breeding areas in the vicinity of Quantico were surveyed and recommendations made as to the use of airplanes under the conditions found there.

An unusually severe outbreak of salt-marsh mosquitoes along the entire Gulf coast during 1925 attracted widespread public attention and led to demands for an investigation of the problem. A rather brief survey of conditions along the coasts of Louisiana, Mississippi, and Alabama disclosed the seriousness of the situation and also the fact that almost no information was available as to the source of the mosquitoes or the extent of the area involved.

#### CREEPING ERUPTION OF MAN

During the preceding fiscal year the malady known as creeping eruption, which is very prevalent in the South, especially in Florida, was shown by the bureau to be caused by a larval nematode worm. As it seemed desirable to determine whether insects serve as vectors for this nematode, or as intermediate hosts, further studies were carried out during the fiscal year just ended. In this connection further epidermological studies have been made and various mites and insects prevalent in the situations where the human-infesting nematode abounds were studied and their nematode parasites cultured. No conclusive evidence has been gained, but much information necessary to a proper understanding of the problem has been collated. This work was

done by W. E. Dove and G. F. White in collaboration with J. L. Kirby-Smith.

### INVESTIGATIONS OF INSECTS AFFECTING DOMESTIC ANIMALS

This work has been carried on under the supervision of F. C. Bishopp with headquarters at Dallas, Tex.

#### SCREW WORM

Investigations relating to the screw worm, which is responsible for heavy losses to the livestock industry of the Southwest, constituted one of the major projects during the year. Studies of the reaction of the screw worm and other blowflies and the house fly to various chemicals were continued. Numerous tests were carried out under laboratory conditions to determine the relative attractiveness for flies of various baits, particularly liver of various ages and prepared in various ways. These tests seemed necessary in an endeavor to eliminate some of the variables which appeared to be affecting the results of the chemotropic exposure tests as carried out heretofore. For this same purpose further tests have been made of the spacing of the jars and the relation of sun, wind, and other factors which seem to influence the tests. A number of the more promising repellent substances were tested in varying dilutions, and some of them were found to be of little value as repellents or even to become attractive when diluted with neutral carriers. A large series of tests of some of the best repellents were carried out under range conditions. The materials were applied to wounds on animals which had become infested with screw worms. The effect of the repellent on the condition of the wound, the duration of the repellent effect, and the rapidity of healing of the wound were carefully noted in each case. A special grade of pine-tar oil with a specific gravity of 1.065 was found to be most satisfactory as a wound dressing when the various factors mentioned above, as well as cost and availability, were considered.

In cooperation with County Agent W. R. Nisbet, of Menard County, Tex., an extensive range-control project was put on against the screw worm. The various recommendations made by this office were followed in the work, but major attention was given to the operation in a systematic way of fly-traps on a large number of ranches. The results of the work during the

spring of 1926 were very encouraging. The number of screw-worm cases as well as the number of cases of the infestation of sheep by wool maggots was held very low at a nominal cost, whereas ranchmen not in the control area suffered serious losses.

#### CATTLE GRUBS

Further information was obtained during the year regarding the distribution of the two species of cattle grubs in the United States, particularly as regards their seasonal occurrence. During the winter and spring of 1926, L. I. Case, of the Virginia Experiment Station, followed a plan of control promulgated by the Bureau of Entomology for the cooperative control of the cattle grub in Burks Garden, Va. During the season practically all of the 2,300 cattle in this valley were treated five times at approximately monthly intervals. The average number of grubs per animal was found to be about 35 for the season. Farmers in the district reported very little annoyance to their cattle from heel flies following the control work. In this area the production of high-class beef cattle is the principal industry, and the cattle grub and heel fly have been found to interfere seriously with the growth and fattening of the animals.

#### THE CONTROL OF FLIES ABOUT DAIRIES

Studies were made during the year with a view to the development of a program for the control of the principal flies which cause annoyance to dairy animals and are responsible for the contamination of dairy products. A number of factors in this program received separate consideration, but the results of the entire system of control were best demonstrated in the cooperative work carried on with the Bureau of Dairying on the Beltsville, Md., farm of that bureau. In this work an effort was made properly to care for the manure and other materials likely to breed flies. Spraying of the animals with pyrethrum extract was practiced with fair regularity, fly-traps were operated, and fans and other means of preventing the entrance of flies into the creamery were used. In this very practical test it was found that a satisfactory degree of control of the house fly, horn fly, and stable fly was secured.

#### SHEEP SCAB MITE AND GOAT LICE

In cooperation with Texas Experiment Substation No. 14 work was continued throughout the year on this

project. Longevity tests with scab mites under varying conditions were continued, and the maximum longevity off the host was found to be 31 days. The tests of the length of time during which scab infestation may remain active in pens after scabby sheep have been removed showed that the pens did not remain infective in these tests more than a few days. Dipping experiments against the sheep scab mite and goat lice were continued but much additional work is necessary before conclusions can be drawn.

#### **INTERNAL MEDICATION FOR THE CONTROL OF EXTERNAL PARASITES**

The experiments begun last fiscal year with the administration of various materials to fowls to determine their effect on external parasites have been completed and the results are soon to be published. Much attention has been directed to the use of salt containing sulphur to protect livestock from the attack of flies. Although this method of procedure is scientifically unsound, it seemed necessary to conduct tests to obtain definite evidence on the subject. These tests show conclusively that the use of sulphurized salt has no effect whatever on the infestation of stock by horn flies, stable flies, or house flies.

#### **INVESTIGATIONS OF INSECTS AFFECTING FOREST AND SHADE TREES**

This work has continued under the direction of F. C. Craighead. No new projects have been undertaken, though continued pressure and demands for assistance from the Gulf States and the southern Rockies show the urgency for field stations in these regions. Western timberland owners are continuously demanding the extension of our services in California and Oregon. Excellent cooperation from private timberland owners, large-scale manufacturers of wood products, and affiliated associations, the United States Forest Service, and the National Park Service has enabled us to conduct investigations that would otherwise have been impossible.

#### **INVESTIGATION AND CONTROL OF WESTERN BARK BEETLES**

Technical administration of several control projects and examinations and surveys as a basis for recommendations as to control and continued research on the bionomics of several species of *Dendroctonus* formed the major activities in this work.

#### **THE SOUTHERN OREGON-NORTHERN CALIFORNIA PROJECT**

During the season of 1925 the fifth annual survey of this extensive project, covering 1,200,000 acres, was completed, bringing to date the results of the control work carried out during the preceding four years by private owners and State and Federal agencies. These results were even more gratifying than was anticipated. Although the season of 1924 was extremely dry, therefore favoring an increase in the destructive beetles, the losses were materially held in check on the treated units. The natural increase amounted to 97 per cent on the untreated area and to only 27 per cent on the treated sections. The total volume of timber saved as a result of these operations is estimated at approximately 50,000,000 board feet. The average cost was only \$2.77 per thousand feet, whereas the stumpage values in this region are from \$5 to \$7 per thousand. The total expenditures for control work to date on private and Government lands have amounted to about \$130,000.

The detailed management and technical analysis of the results of this large project, really amounting from our standpoint to a large-scale experiment, have developed some very valuable information as to the technique and administration of control as well as much of scientific value on the bionomics of the insects. Some of the more outstanding results as reported by F. P. Keen, who directed the work, are, "that the administration of control is more economical on smaller units than by large blocks as first undertaken in this project; that the influence of control is extremely local and does not extend to more than 1 mile from the area treated; that fall and winter treatment give better results than spring work; and that the most beneficial results from control were obtained on units where treatment was conducted against an increasing epidemic." The effects of treating endemic infestations seem to be overshadowed by other factors. In this region an epidemic status is placed at 65 trees per section. Many private owners in this region have been so impressed with the excellent results that they are considering control operations as of the same importance as fire control. In other words, the timber is being cruised annually and wherever an epidemic condition exists control work is immediately undertaken.

### THE KAIBAB NATIONAL FOREST AND GRAND CANYON NATIONAL PARK

Further control work on this area was conducted in 1925. On the north end of the epidemic area the Forest Service spent some \$5,000. In the extreme south on Greenland Plateau—an isolated area within the Grand Canyon National Park—an expenditure of between \$4,000 and \$5,000 by the National Park Service was required. At present the general situation is very good. A very marked decrease in this epidemic occurred last year. The new infestation following the 1925 flight of beetles is estimated at about 3,000,000 board feet—a reduction of over 85 per cent from that which existed the preceding year. This marked decline can be attributed in part to control measures though by far the most important influences were natural agencies. A careful analysis of the factors bringing about this decline points emphatically to unusual weather conditions existing during the summers of 1924 and 1925. The extremely high winds during May and June of 1925 caused thorough desiccation of the infested trees, resulting in high mortality in the maturing larvæ.

During the late summer of 1925 a survey of the results of the previous years' control work was made. It was found that a reduction of 78 per cent was obtained on treated areas whereas adjacent untreated sections increased 73 per cent. There is every reason to believe that had funds been available to treat the entire infestation in any one year, the epidemic could have been effectively checked.

### BITTERROOT CONTROL PROJECT

This project was started in May, 1925, in an effort to check the spread of an epidemic of the mountain pine beetle which has been sweeping south along the west side of the Continental Divide since 1910. Heretofore the losses have been confined chiefly to inaccessible stands but the insects now threaten merchantable timber. Recently the advance of this epidemic reached the headwaters of the Bitterroot River where over 200,000,000 board feet of yellow pine and lodgepole pine has been destroyed in the last three years. During the season of 1925 a limited amount of control was attempted, over 8,233 trees having been treated at a cost of \$7,535. The effect of this work was intangible, as the number of trees treated was not

sufficient to make much of an impression on this heavy infestation. Because of the value of the timber at stake a more extensive program was initiated in 1926 which it is hoped can be continued until the epidemic is under control.

### INDEPENDENCE CREEK PROJECT

This project was instituted in 1924 on an experimental basis, having as a primary objective the testing of the effectiveness and economics of control of the mountain pine beetle in white pine. Control measures were carried on during the seasons of 1924 and 1925 and will be continued for at least two more years. Even though the infestation was increasing, a reduction of 60 per cent of the previous year's loss was achieved as a result of the first season's work, which more than justified the expense of the operation.

### RELATION OF INSECT LOSSES TO FOREST MANAGEMENT

A survey was made during the summer of 1925 of 14 selected cut-over areas on national forest lands in district 5. The results of this study show that on certain sites bark-beetle losses take a heavy toll of the trees left for seeding of the area and for increment for a second cut.

An analysis of the growth rings of some 3,000 trees indicates that the western pine beetle shows a tendency to select the more slowly growing trees. This applies to the trees left on cut-over areas as well as to those in virgin stands. This discovery has opened up the possibility of eliminating the trees susceptible to insect attack through selective logging operations and through marking in timber-cutting operations.

### INTERRELATION OF INSECTS AND FIRES

A further study of the extent to which bark beetles may supplement the damage caused by fires in western yellow pine forests has been made on the Northfork burn which occurred on the Sierra National Forest in 1924. This burn covers 6,000 acres, representing a variety of conditions caused by the fire. A thorough survey has been made of the entire burn and the surrounding area, sample plots were established, and over 4,000 infested trees marked and mapped. The results which will be available in 1927 will show the extent of insect damage in each of several types of injury due



to the fire. These studies are supplemental to others carried out in southern Oregon in 1918 to 1920.

#### COOPERATION WITH THE NATIONAL PARK SERVICE

For some years the bureau has been cooperating with the National Park Service by extending technical advice, making examinations of insect depredations, and occasionally detailing entomologists to assist on the more serious problems. During the fiscal year cooperation was established on a much firmer and more comprehensive basis by means of a transfer of \$4,000 from the National Park Service to this bureau. This enabled the bureau to provide additional personnel to take charge of and direct the control work on several serious infestations which developed the preceding year.

In the Yellowstone National Park some 7 miles of roadway was sprayed to protect the bordering lodgepole pines from defoliation by a sawfly and needle tyer. The sprayer was loaned by the gipsy moth laboratory of this bureau. Most satisfactory results were obtained, the sprayed area contrasting very strikingly with the adjacent untreated timber behind. Some 50 square miles of lodgepole pine forest has been almost completely destroyed by the combined attack of these two insects but the outbreak is now subsiding and prompt control measures saved the most frequented portions of the infested area.

In the Crater Lake National Park control operations were conducted against an increasing infestation of the mountain pine beetle. Approximately 4,000 trees were treated. The results of this work were most gratifying, showing a marked reduction in the infestation. On the greater part of the area practically complete control was obtained and only a small portion will need recleaning in 1926.

Cooperative control was likewise conducted against the Black Hills beetle in the Grand Canyon National Park. A more detailed account of this work is reported under the Kaibab control project.

A small but serious infestation was reported from the Devils Tower National Monument in Wyoming. Prompt control measures were conducted under the supervision of the Northern Rocky Mountain Field Station and it is hoped that complete protection will result.

#### COOPERATION WITH PRIVATE TIMBERLAND OWNERS

Each year the bureau is called upon by private timberland owners for more assistance in making examinations of beetle-infested timber and recommending proper control procedure. Several projects of this character were undertaken covering a total of nearly 100,000 acres and treatment of some 10,000 trees.

**PANDORA DEFOLIATION.**—In the last annual report attention was called to the increased bark-beetle attack in western yellow pine defoliated by the Pandora moth. During the past season it was possible to collect more concrete data on this interrelation. A private company holding timberland in this defoliated region became alarmed at the increased number of dying trees and instituted control measures. It was found that there was a direct correlation between the amount of timber killed and the percentage of defoliation. J. E. Patterson reports: "On the areas receiving 80 or more per cent defoliation in the years 1919 to 1924 there was an average of 80 trees attacked per section by bark beetles, some sections running as high as 300 trees. In the adjacent timber just out of the defoliated belt the bark-beetle infestation did not exceed an average of 40 trees per section. The results from control under these conditions can not as yet be foretold."

#### INSECT PROBLEMS IN THE SOUTHEAST

Late in the year the temporary field base established at Asheville, N. C., to study in more detail the several important forest insects in the Southeast was put on a permanent basis with the appointment of an assistant entomologist. Through arrangements with the Appalachian Forest Experiment Station we are using their field laboratory on the Pisgah National Forest. Several permanent sample plots have been established for the more detailed study of environmental factors contributing to epidemics of the southern pine beetle and of the interrelations of insects and forest fires. Valuable biological data pertaining to the southern pine beetle and associated insects were obtained during the season of 1925. More evidence supporting the incidence of these beetle outbreaks and drought has been obtained. The phenomenal increase of the southern pine beetle during such periods is partially explained by



demonstrating that with favorable conditions four and possibly five generations may occur during the season in this locality with a potential increase of nearly 1,000 per cent in each generation.

The insect problems associated with turpentining and reforestation in the Gulf States received some attention.

#### WHITE-PINE WEEVIL

The undertaking of a new project for the investigation of the white-pine weevil in the Northeast, made possible by contributions from private timberland owners, was reported last year.

Much of the field season was spent studying the various parasites and predatory enemies and a number of species were collected and determined. Several hundred leaders collected from various localities were caged in order to get some information on the species common in the various localities. Direct control was carried out in a number of plantations. All the leaders weeviled in 1925 were removed and either caged or burned. In other plantations many of the trees were coated in various places with sticky tree-banding material. These experiments will be carried further this year. The possibility of indirect control of the injury through proper forest management has been studied very fully, but much work remains to be done. Many permanent and semipermanent sample plots have been laid out in various ages, sites, and mixtures, and on different exposures. From the information already obtained this phase of the study bids fair to be of paramount importance in finding adequate means of preventing the injury.

#### INVESTIGATIONS IN THE LAKE STATES

The most important problem handled from the St. Paul field station during the year has been the tip-moth studies in the Forest Service pine plantations at Halsey, Nebr. This eastern tip moth (*Rhyacionia frustrana* Comst.), accidentally introduced into these plantations, has been causing enormous damage. Investigations have proceeded along two lines: one, an attempt to develop a method of treating nursery stock so as to prevent the dissemination of the moth into new areas; the other, aimed at controlling the present infestation through the introduction of parasites. Several effective dips for nursery stock have been experimentally tested. About 20 species of parasites have been introduced and it will be several

years before it can be determined if these will become established.

The spruce budworm and jack pine sawfly have received attention in northern Minnesota. The hemlock looper is reported very injurious in some portions of Wisconsin.

#### INSECTS AFFECTING FOREST PRODUCTS

Tests of wood preservatives for both crude and finished forest products, as well as poisons for wood-pulp products, have been continued both at Falls Church, Va., and on Barro Colorado Island, Canal Zone, Panama, by T. E. Snyder. Woods treated with various metals by the United States Bureau of Standards, using a machine in which metal wire is run through an electric arc by compressed air, have not lasted well in service tests in contact with the ground in Panama. Because of the contraction and expansion of the wood, the metal chips off and the wood is attacked by termites. In the case of such treatments for cabinet work, furniture, etc., indoors, conditions might be more favorable for success.

Some of the test woods impregnated by the Forest Products Laboratory of the Forest Service with sodium fluoride, alone and in combination with other chemicals, have been attacked by termites after one year's test in the ground in Panama. Treatments with such soluble salts would probably be more effective as preservatives for interior woodwork not in contact with the ground where moisture causes them to leach out.

A series of woods impregnated with war-time chemicals supplied by the United States Chemical Warfare Service are under test.

On recommendation of this bureau a large public-service corporation in southern California has recently purchased 10,000 poles impregnated for their entire length with coal-tar creosote to prevent termite damage in a region where the whole pole is subject to serious damage by termites.

Preliminary tests indicate that termites which live above ground and do not burrow in the earth (Kalotermitidae) will not attack untreated fiber or composition wood-pulp boards. If so, this will be a great advantage, since wood with a grain, if used untreated as interior finish, is badly attacked by termites.

Model or demonstration "termite-proof" buildings are being constructed on Barro Colorado Island, Canal Zone, Panama, and at New Orleans, La. These buildings are constructed en-

tirely of woods impregnated with various chemicals, and the interior finish is treated fiber board. They are being used in connection with the educational propaganda for such slight modifications of city building regulations as will prevent losses from termite damage, with the especial purpose of protecting the small householder.

Manufacturers of implement handles made of seasoned hardwoods are adopting the Bureau of Entomology's recommendations to paint their products, thus overcoming the trade prejudice for white sapwood and enabling the use of heartwood which is not attacked by powder-post beetles and is just as suitable when of the same grade as the sapwood.

A survey of defects in timber caused by insects and their relation to the conservation of timber, especially hardwoods, indicates that much of this damage can be prevented, and that closer utilization of "sound wormy" timber will aid in forest conservation.

Orthodichlorobenzene continues to be effective in killing borers and powder-post beetles in woodwork and furniture.

Biological work is being conducted with reference to subspecies or subraces of *Reticulitermes*, the most destructive genus of termites in North America and Europe. Breeding experiments within the species and by hybridization are to be undertaken. Studies of symbiotic Protozoa are also to be made in both Europe and North America.

#### INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS

Investigations of the boxwood leaf miner have been continued and expanded somewhat through cooperation with the Bureau of Plant Industry of the Pennsylvania State Department of Agriculture, the Andorra Nursery Co., and estate owners. A molasses-nicotine spray has been tested in the neighborhood of Washington and fumigation work carried on near Philadelphia. The effect on both insect and plant has to a considerable extent been determined although the results of these investigations will not be ready for publication for at least another year. In most infestations by the boxwood leaf miner, especially those of several years' duration, the plants have been considerably devitalized and a disease which is normally secondary becomes of primary impor-

tance. The Federal Bureau of Plant Industry has been giving this disease some attention.

Through the cooperation of S. M. Dohanian of the gipsy moth laboratory a shipment of *Tetrastichus xanthomelaenae* Rond., a small hymenopterous parasite of the eggs of the elm leaf beetle, were obtained for liberation on the Taylor estate at Gordonsville, Va.

#### BEE-CULTURE INVESTIGATIONS

The work of the bee-culture laboratory has been continued under the supervision of James I. Hambleton.

##### BEHAVIOR OF BEES

The determination of the brood-rearing activity of various foreign races of bees has been carried on to ascertain particularly any difference existing between the various races in their propensity to breed out of season in this country. Experimental work on queen rearing, begun last year, has been continued.

Computations are being made of data collected on the Delaware coast during 1925, where an experimental apiary was established. This apiary had access only to an artificial honey flow, and it is hoped that the data will throw some light on the reaction of bees to weather factors alone.

A continuous recording automatic scale, carrying a colony of bees, has been installed at the laboratory. The most minute changes in weight of the colony, as affected by weather factors and other outside stimuli, are continuously recorded on a moving chart. This instrument will give a curve of general colony activity for the entire year.

Experiments started last summer regarding the reactions of bees to intensities and colors of light are being continued. The spectral filters in use are being standardized for three factors; wave length of light transmitted, actual energy transmitted (i. e., intensity), and stimulating effect of each kind of light on the bee's eye. After having done this it will be possible to plot a curve showing the relative sensitivity of a bee's eye to light of various colors. By attempting to train the bees to associate food with a certain wave length of light as against another wave length of the same stimulating efficiency, it may be possible to ascertain whether they can actually distinguish colors, or are color blind, a point much in dispute.

The work on the color grading of honey was finally completed by the issuance of Department Circular 364, The Color Grading of Honey. In cooperation with the Bureau of Agricultural Economics further work on the grading and standardization of practically all classes of commercial honeys has been done during the year. It is hoped that much confusion concerning the classes and grades of honey will be done away with by the adoption of classes and grades as recommended in a forthcoming publication.

Shortly after the beginning of last fiscal year investigations were started on certain phases pertaining to methods of managing colonies of bees during the fall. Experience indicates that if colonies are in what appears prime condition in the fall, but slight loss is entailed during the winter and little attention need be given them the following spring. The purpose of this experiment is to ascertain just what factors should be present in the colony during fall to insure strong colonies for spring. Spring and winter losses, resulting from faulty management of colonies during the fall, amount to hundreds of thousands of dollars annually.

#### PHYSIOLOGY OF BEES

During the past winter three gross analyses of the disemboweled bodies of worker bees were made with a view of determining some of the exact physiological changes taking place in the body of the bee during its quiescent period. It is during this period that heavy losses of colonies occur over the entire country. One of the results of the analyses showed, contrary to expectations, a gradual increase in the ether extract content in the body of the worker bee from December to March.

In cooperation with the Bureau of Home Economics preliminary studies are being made of the food value of honey. The present phase of the work deals largely with the vitamin content of extracted honey. Feeding experiments in this connection are being done on white rats and guinea pigs.

#### DISEASES OF BEES

Department Circular 284, The Sterilization of American Foulbrood Combs, was issued in March. This circular, of a technical nature, gives the results of sterilization with various materials of wax combs containing spores of American foulbrood. It was found that a 20 per cent solution

of formalin in water was efficient and cheap for this purpose. A further study along this line is being made of the loss of formalin from the water solution during the sterilization process.

An attempt has been made to culture *Bacillus larvæ* directly from infected honey. Even when the honey is infected to an unusual degree it is exceedingly rare that success is attained. In this connection, the detection of spores of *Bacillus larvæ* in honey has been accomplished by means of ultra filters. This method is yet too expensive to justify hope for its adoption as a routine method of detecting commercial honeys infected with spores of *Bacillus larvæ*.

In the routine diagnostic work on bee diseases 784 samples of brood and adult bees have been examined. There is no evidence of falling off in the number of samples of either American foulbrood or European foulbrood, the two most serious brood diseases of bees. In the examination of adult bees no cases of infestation by *Acarapis woodi* have been found.

Work the past year dealing with the relation of fungi to honeybees has brought to light five species of *Aspergillus* actively pathogenic for adult bees and brood, and three others pathogenic for adult bees, the pathogenicity of these latter for brood not having been determined. One of these apparently undescribed organisms appears to have been the cause of an epidemic in a Connecticut apiary. At least two other species and genera of fungi collected from bees have been found to be pathogenic for adult bees. An active toxic substance, for honeybees, has been extracted from a pathogenic species of *Aspergillus*. The nature of this toxin has been partially determined.

#### BEEKEEPING REGIONS IN THE UNITED STATES

Lack of funds has prevented doing the most desired work on this subject, although specific information is being constantly gathered concerning the principal honey-producing regions of the United States. Much field work needs to be done to collect all the data wanted.

Through the cooperation of some 2,000 correspondents, who are being trained in reporting the blooming dates of honey plants, floral isophanes for the principal nectar-producing plants are being worked out.

### DEMONSTRATIONS IN BEEKEEPING

As this office has no field representative, little active work has been done on this project. This, in turn, has been a handicap, as it leaves the office correspondence as the only means of liaison between the office and the field. To overcome this to a certain extent various members of the staff have attended meetings of beekeepers in the field. Twenty-five such meetings were attended.

### INSECT-PEST SURVEY

The work of the insect-pest survey has been carried on as in the past under the direction of J. A. Hyslop.

The survey has now functioned five years and is recognized as an integral part of the cooperative work of the bureau and the entomological agencies existing in the several States and the Dominion of Canada.

During 1925 the survey completed volume 5 of its Monthly Bulletin, consisting of 8 numbers and 397 pages of text material, and an index of 40 pages. Numbers 1 to 4 of volume 6 were also issued during the fiscal year, comprising 123 additional pages of text material. Urgent material was handled in the form of special reports as heretofore.

Additional work on the common-name index instigated by the survey and assumed by the American Association of Economic Entomologists has been carried on, and a supplementary list to the one published in 1925 was presented to the association for its approval. This work will be continued through the current year.

The work on the correlation of climatic conditions with the abundance of the chinch bug has advanced but little during the past year because of the ever-increasing mass of material which the survey is handling.

The survey still contemplates incorporating in its files all the statistical data on economic insects of North America which have been published in the past. Of course the scope of this work is so great that it can not be attempted until the technical force of the survey is augmented. This same condition exists with relation to the atlas of economic entomology and the host-plant index projected in previous reports.

The survey files now contain references to over 1,900 species of insects reported as of more or less economic importance. These insects represent practically all the major orders and

fall into 1,356 genera. The ratio of new pests to those already reported is of course diminishing each year. Our files are rapidly becoming representative of the economic entomological situation in North America and additional names in the future will be largely those of unusual pests or introduced species.

The cooperation with the States is as enthusiastic and complete as possible. The number of collaborators has increased from 55 in 1921 to 71 on July 1, 1926.

The demand for the Survey Bulletin as a means of keeping closely in touch with the entomological situation throughout the country, by entomologists, extension workers, teachers, produce exchanges, and general science services has greatly increased.

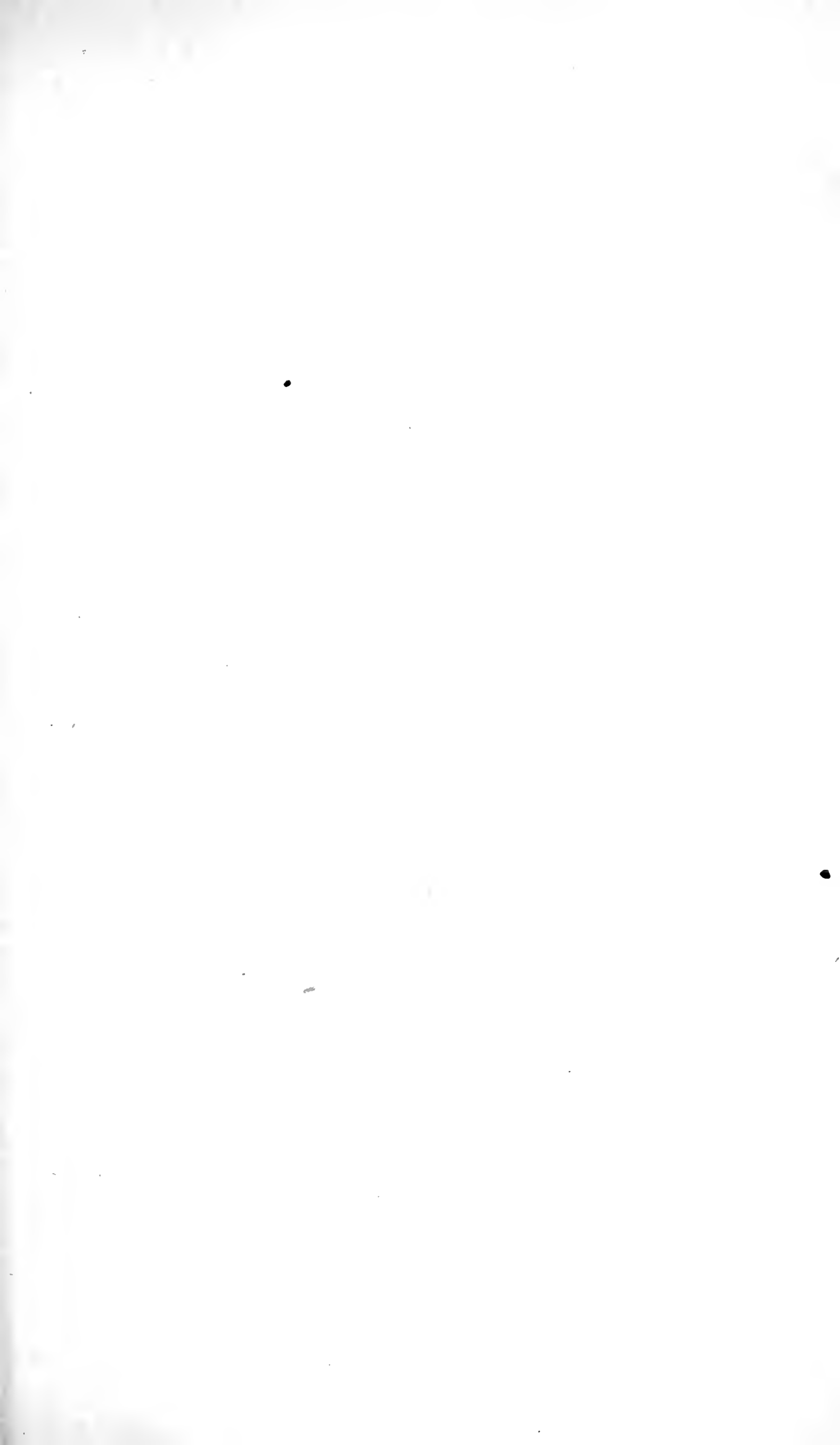
### TAXONOMIC STUDIES OF INSECTS

The accurate identification of the insects on which the experts of the bureau are working is a matter of prime importance and therefore there has grown up gradually in the force a corps of specialists in the various groups of insects. These specialists are of high authority in the field of entomological science and their judgments are absolutely dependable. Therefore the workers on economic problems are soundly based by these men as to exact identities and group classification.

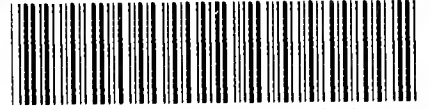
The mere identification of the species sent in from the field by bureau workers, by the Federal Horticultural Board, by the workers in the State experiment stations, and by collaborators at home and abroad is an enormous labor. But this is not all. Every one of these workers is a research man who produces and who is at work constantly on the study and description of species new to science and in the preparation of monographic papers for the use of entomologists everywhere.

To systematize the administration of this class of work it has been made a division of the bureau with S. A. Rohwer in charge. From his report for the fiscal year it appears that nearly 10,000 species were identified during the year from 5,800 lots sent in. The larger part of this work, it should be stated, was for the Federal Horticultural Board, which bases its important decisions upon these identifications. The research work done by these taxonomists in addition to this has been very large and of a high character.





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